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ENERGY DEVELOPMENT AND POWER GENERATING COMMITTEE

PANEL SESSION: STATUS OF INTERNATIONAL INTERCONNECTIONS AND ELECTRICITY DEREGULATION IN AFRICA

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Wednesday, June 9, 2004, Room Silver, 9:00 a.m.–5:00 p.m.

EXTENDED PANEL SESSION SUMMARIES

Sponsored by: International Practices for Energy Development and Power Generation Subcommittee

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Track 1: Active Load Participation and Its Impact on Markets

This Panel Session discussed Electricity Deregulation in Africa

The panel presented the status and future prospect of electricity infrastructure from the viewpoint of Generation and Transmission Development, Global Deregulation trends and policies, Global Research and Development (R & D) and the Global transition to knowledge based economies. The panel therefore attempted to evaluate models and policies that are near term, mid term and long term.

Interconnection of electric power systems of regions, states and individual territories is acquiring a growing scale of importance in world practice as previously recognized by this body. Examples of this influence and studies to date were presented. Key to the presentations was focus on projected development of power pools in various regions and their interconnections domestically and internationally. There are many benefits of this tendency because of the so-called system effects that lead to improving economical, ecological and technological efficiencies of the joint operation of electric power systems. The effort to limit GHG emission is one such major benefit. Another important benefit with institutional wide implications is the modeling of these initiatives. The raw resources data of these emerging energy initiatives integrated with global 'lessons learned' allows for the creation of dynamically linked knowledge bases and their derivatives. These in turn serve to efficiently drive these emerging initiatives while creating information density. The EPRI road Map initiative is one such example.

Africa, Asia and the Middle East are very favorable regions for electric power grid creation and using the above system effects on account of the different levels of economic development in different countries of the region, different placement of fuel and energy resources, and consumers, etc. Therefore, the analyses of the present status and prospective trends of Africa, European and Middle Eastern

Electricity interconnections and efforts to improve efficiency and limit GHG emission and bridging the digital divide are very important problems.

The Session presented some results of studies in this area at this time.

Presenters and Titles of their Presentations are:

1) Pat Naidoo, Senior General Manager of Transmission, Eskom, Johannesburg, South Africa; l Musaba, W. Ballet, and A. Chicova, Harare, Zimbabwe. Towards Developing a Competitive Market for Regional Electricity Cross Border Trading: The case of the Southern Africa Power Pool (Paper 04GM0755).

2) A. Majeed H A Karim, Secretary to the Board of Directors, GCC Interconnection Authority (GCCIA), Kingdom of Saudi Arabia; N.H. Al Maskati, Deputy Chairman of Board of Directors, Kingdom of Saudi Arabia; and S. Sud, V.P. Energy Division, SNC–Lavalin Inc., Montreal, Canada. Status of the GCC Electricity Grid System Interconnection (Paper 04GM0660).

3) F. T. Sparrow, Brian H. Bowen, and Zuwei Yu, Power Pool Development Group, Purdue University, West Lafayette, IN, USA. Economic Benefits and Strategic New International Transmission in the Southern African Power Pool (SAPP) and West African Power Pool (WAPP) (Paper 04GM0758).

4) Wei-Jen Lee, Director, Energy Systems Research Center, University of Texas at Arlington, TX, USA. The Environmental Impact of Large Scale Hydroelectric Development: Lessons from Three Gorges (Paper 04GM0584).

5) B.K.Blyden, BBRM Investments, LLC, Elk Grove, CA, USA. African Power Pool Interconnections Development: A Foundation for Bridging the Digital Divide (Paper 04GM0927).

6) James Momoh, Director, National Science Foundation, Arlington, VA, USA. US/African Power Research and Education Activities: Challenges, Experiences and Opportunities (Paper 04GM1268).

7) Ahmed Faheem Zobaa, Cairo University, Giza, Egypt. Status of International Interconnections in North Africa (Paper 04GM0509).

8) Lori Pottinger, International Rivers Network, USA. Large Hydro-fueled Grid Schemes for Africa: A Recipe for Disaster? (Paper 04GM0481).

9) Moshin Chen, Professor Emeritus, Energy Systems Research Center, University of Texas at Arlington, TX, USA. The Energy Challenge (Paper 04GM1083).

10) Raymond Johnson, Engineering Consultant, BBRM Investments, Altadena, CA, USA. Impact of Privatization and Deregulation on Infrastructure Development in Africa (Paper 04GM0400).

11) Jan A de Kock, Potchefstroom University, South Africa. Status of International Interconnections and Electricity Deregulation in Africa—An Overview of the Current Status in Southern Africa (Paper 04GM1053).

Each Panelist spoke for approximately 20 minutes. Each presentation was discussed immediately following the respective presentation. There was a further opportunity for discussion of the presentations following the final presentation in both the morning and afternoon sessions.

The Panel Session was organized by Tom Hammons, Chair of International Practices for Energy Development and Power Generation (University of Glasgow, UK), and Bai Blyden, BBRM Investments, Elk Grove, CA, USA.

Tom Hammons and Bai Blyden moderated the Panel Session.

1). The first presentation was entitled: Towards Developing a Competitive Market for Regional Electricity Cross Border Trading: The case of the Southern Africa Power Pool. It was prepared by Pat Naidoo, Senior General Manager of Transmission, Eskom, Johannesburg, South Africa; l Musaba, W. Ballet, and A. Chicova, Harare, Zimbabwe. Pat Naidoo presented it.

Pat Naidoo is Senior General Manager of Transmission, Eskom, Johannesburg, South Africa. He is a registered professional engineer, a graduate in Electrical Engineering from the University of Durban Westville in South Africa and a postgraduate with an MBA from Stamford University in the USA. Presently, he is an engineering doctorate student with the University of Warwick in Coventry, United Kingdom.

Mr. Naidoo joined Eskom 19 years ago as an engineer in training. In 1990 he was promoted to Principle Engineer of Regional Engineering. In 1995, he was promoted to Senior Manager in charge of the Kwa -Zulu Natal and Free State Area of the Eskom National Grid. He was promoted to Senior General Manager of Eskom's Transmission Division. In 2001, Energy Trading was added to his accountabilities. In 2002, he was appointed as Technical Director on the board of Motraco, the Mozambique Transmission Company, a joint venture initiative between South Africa, Mozambique and Swaziland. In 2003, Mr. Naidoo participated in the planning for the Western Power Corridor; a joint venture between Eskom of South Africa, BPC of Botswana, Nampower of Namibia, ENE of Angola and SNEL of the Democratic Republic of Congo. This is focused on the development of 3500 MW of run of the river hydro generation and the transmission of the energy on two HVDC circuits over 3000 km.

2). The second presentation was on status of the GCC Electricity Grid System Interconnection. A. Majeed H A Karim, Secretary to the Board of Directors, GCC Interconnection Authority (GCCIA), Kingdom of Saudi Arabia; N.H. Al Maskati, Deputy Chairman of Board of Directors, Kingdom of Saudi Arabia; and S. Sud, V.P. Energy Division, SNC–Lavalin Inc., Montreal, Canada prepared it. Satish Sud presented it

Recognizing the benefits of interconnection of their power grids, the six Arab states of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) had a study carried out in 1990 to define an Interconnection Project and to determine its feasibility. The present studies have re-confirmed the technical feasibility, and the economic and financial viability of the Project.

The study recommends an AC interconnection of the 50 Hz systems of Kuwait, Bahrain, Qatar, UAE and Oman with a back-to-back HVDC interconnection to the 60 Hz Saudi Arabian system. Steps are now being made to take the Project to market and work towards its implementation.

This was examined and discussed in the presentation.

A Majeed H A Karim is a chartered Electrical Engineer and a Fellow Member of the IEE in the UK. He is also a Fellow Member of the Bahrain Society of Engineers, Bahrain. He obtained his PhD from the University of Bradford, West Yorkshire, UK in 1986 in Power Engineering and has a Masters Degree in Power Systems from UMIST and Bradford. He is presently Advisor to the Undersecretary of the Ministry of Electricity and Water

Nabeel Al-Maskati is Assistant Undersecretary for Planning and Projects at the Ministry of Electricity and Water in the Kingdom of Bahrain and the Vice Chairman of the Gulf Cooperation Council Interconnection Authority. He is an Electrical Engineer and graduated in 1975 with a Bachelor Degree in Engineering from the American University of Beirut in Lebanon. He holds a PhD in Electrical Engineering from the University of Texas at Austin 1978. His field specialization is computer application in Power System Planning and Operation. Al-Maskati is a member of the Economic Development Institute of the World Bank and Vice Chairman of the Gulf Cooperation Council Interconnection Authority.

Satish Sud is Vice President of Power Systems in the Energy Division of SNC Lavalin, Canada. He is an electrical engineer with over 34 years of experience and is responsible for the development and management of the Power Systems Group which undertakes electrical transmission and distribution projects, electrical system and energy studies, master plans, power sector reform and restructuring studies, and economic and financial studies. He has directed numerous electrical generation, transmission planning and system design studies, both in Canada and overseas. He was the project manager for planning studies to determine the techno-economic feasibility of various interconnection projects where both AC and DC alternatives were considered. He has also developed master plans for electrification and national energy plans for several countries. He is a member of the Order of Engineers of Quebec, Institute of Electrical and Electronic Engineers (IEEE) and the Institution of Electrical Engineers (IEE) (Fellow).

3). The third presentation was entitled: Economic Benefits and Strategic New International Transmission in the Southern African Power Pool (SAPP) and West African Power Pool (WAPP) It was prepared by F. T. Sparrow, Brian H. Bowen, and Zuwei Yu, Power Pool Development Group, Purdue University, West Lafayette, IN, USA.

The Power Pool Development Group at Purdue University is collaborating with electricity utilities in 26 countries of Africa in the development of regional long-term capacity expansion planning decision support tools. In the case of the Southern African Power Pool (SAPP), the Purdue modeling team has been in partnership with the SAPP Planning Sub-Committee and member utilities from the 12 countries that constitute the Southern African Development Community (SADC). With the West African Power Pool (WAPP), the team is working with the Secretariat of the 14 county member Economic Community of West African States (ECOWAS), and their respective utilities and WAPP coordinating working groups. Their studies will be summarized in the presentation. Professor Sparrow will make it.

F.T. Sparrow has been professor of industrial engineering and economics at Purdue University since 1978. He has a Ph.D. in economics and operations research from the University of Michigan. He is director of the Purdue Power Pool Development Group (PPDG) and Center for Coal Technology Research (CCTR) with his interdisciplinary interests focusing on energy modeling and analysis. Honored as a Ford Foundation research professor, he is also a consultant to various agencies and utilities.

Brian H. Bowen is associate director of the Power Pool Development Group (PPDG) at Purdue University, where he received his Ph.D. in industrial engineering. Before his association with Purdue he worked in West Africa and Southern Africa for 17 years in engineering education and on energy (UK contracts). His research interests are in economic development and power pool cooperative infrastructures.

 # Zuwie Yu is an associate professor of industrial engineering (by courtesy appointment) at Purdue University and is a senior analyst with Purdue's State Utility Forecasting Group (SUFG). His research is in energy system optimization and risk analysis. He received his PhD in electrical engineering with a minor in operations research from University of Oklahoma.

4). The fourth presentation considers environmental impact of large-scale hydroelectric development and the lessons from Three Gorges. It was made by Wei-Jen Lee, Energy Systems Research Center, University of Texas at Arlington, TX, USA

As a global recognition and concern over potential effects of climate change due to increasing levels of greenhouse gases in the atmosphere, hydroelectric power becomes one of the most favorable renewable energies with no greenhouse gases emission. Africa is the continent that is rich in potential hydropower. However, most of the schemes are not fully developed. There are general consents in the global community to develop hydroelectric power in this region to benefit both the local community and neighboring countries. This presentation discussed the issues that have been encountered at the "Three Gorges" development in China. The lessons will be valuable references for similar developments in Africa.

Wei-Jen Lee received his B.S. and M.S. degrees in Electrical Engineering from National Taiwan University, Taipei, Taiwan, in 1978 and 1980, respectively, and a Ph.D. degree in Electrical Engineering from the University of Texas at Arlington in 1985. Since then, he joined the Electrical Engineering Department at University of Texas at Arlington. He is currently a Professor with the Electrical Engineering Department and the Director of the Energy Systems Research Center. He has been involved in research on power flow, transient and dynamic stability, voltage stability, short circuit, relay coordination, power quality analysis, and deregulation for utility companies.

5). The next presentation discussed African Power Pool Interconnections development and whether it is a foundation for bridging the digital divide. It was prepared and given by Bai K Blyden, Engineering Consultant, BBRM Investments, CA, USA

The presentation attempted to recommend and demonstrate an opportunity for African policy makers to utilize the information density created by the planning of some of these energy development initiatives to integrate with international R&D in the growing field of knowledge management.

The South African power pool (SAPP), West African power pool (WAPP) and the initiatives in North Africa with interconnections to the Middle East represent vast knowledge domains. Modeling the intent of these initiatives (i.e., a given power plant, series of plants or development projects in a given system) generates technical and societal ‘impact’ data across academia, industry and other sectors of society. Several studies were cited to illustrate the growing importance of ‘knowledge management’ versus ‘knowledge transfer’ and the resulting possibilities.

In turn the principal studies on African interconnections were cited as foundation candidates toward building these knowledge bases. Contemporary events such as The California Energy Crisis and projects such as the Three Gorges Project in China and the Brazilian Hydro experience were also cited for their own internal experience.

Bai K Blyden is an Engineering Consultant, BBRM Investments, LLC, USA. He received the degree of MS.EE from Moscow Energetics Institute in 1979. He works as an Engineering Consultant in the US Power Industry where he resides. Mr. Blyden has worked on over thirty power plants and their associated interconnections throughout his career in various capacities of distribution planning, electrical control systems design, management and construction. He has been employed by the major AE firms including Bechtel, ABB Asea Brown Boveri, Stone & Webster and Gibbs & Hill. He is a member of the IEEE International Practices Subcommittee and serves as consultant to GENI (Global Energy Network International).

Bai Blyden is the author of several papers on African Energy Development published in various IEEE publications (1983-2000). He has lectured extensively on African Energy Development issues to Institutions and more recently to Investment groups. He was one of the early advocates of an all Africa Grid and presented a conceptual framework and technical analysis for a centralized African Power pool with links to North Africa at the first Region 8 IEEE conference held in Nairobi, Kenya, 1983.

6).   The sixth presentation was entitled: US African Power Research and Education Activities: Challenges, Experiences and Opportunities. It was prepared by James A. Momoh, Program Director, Electrical & Communication Systems (ECS), National Science Foundation, Arlington, VA, USA. Joe H. Chow, Rensselaer Polytechnic Institute, Troy, New York, USA presented it.

James A. Momoh received the B.S.E.E. degree from Howard University in 1975, the M.S.E.E. degree from Carnegie Mellon University in 1976, the M.S. degree in Systems Engineering from the University of Pennsylvania in 1980 and the PhD degree in Electrical Engineering from Howard University in 1983. He is a former Chairman of Howard University Department of Electrical and Computer Engineering.

His current research activities are concentrated in stability analysis, power system security and development of computational tools for power system reliability assessment, optimal power flow for restructuring of the power industry, and intelligent system application of artificial neural networks, fuzzy logic and genetic algorithms to power system automation for utility firms, aerospace and naval systems.

Currently at NSF, he initiated the development of interdisciplinary program in Power Systems, Economics, Environmental and System theory for secured, efficient power networks. He is the coordinator of the US-Africa Research and Education Collaboration in Power/Energy, Information Technology (IT) and Environment, which have led to joint research efforts between US professors and their counterparts in Africa. He is a Fellow of the both IEEE and Nigerian Society of Engineers (FNSE) and a recipient of many numerous awards.

7). The seventh presentation discussed status of international interconnections in North Africa and was prepared by Ahmed Zobaa, Cairo University, Egypt. Tom Hammons presented it.

Interconnections between neighboring utilities are becoming increasingly vital for the implementation of an open energy trading market and to increase the reliability of power systems. The power utilities of the Arab countries in North Africa and the Middle East have made considerable investments in extending transmission system interconnections and power-transfer corridors at various voltage levels to facilitate cross-border trading of electric power. Progressive development of interconnections, either between neighboring countries or within separate island power systems in one country, can be affected by the distances separating capital cities, power pools, population density and the Sahara Desert. This was discussed and analyzed.

Ahmed Faheem Zobaa received the B.Sc. (hons), M.Sc. and Ph.D. degrees in Electrical Power & Machines from the Faculty of Engineering at Cairo University, Giza, Egypt, in 1992, 1997 and 2002. Currently, he is with the Department of Electrical Power & Machines, Faculty of Engineering, Cairo University. He regularly reviews papers for eight IEEE Transactions especially IEEE/PES transactions and six journals in his areas of interest. He is author or co-author of many refereed Journal and Conference papers. His areas of research include harmonics, compensation of reactive power, power quality, photovoltaics, wind energy, education and distance learning. He is an Editorial Board member for the *International Journal of Power and Energy Systems*, and for *Electric Power Components & Systems*.

8). The next presentation was on large hydro-fueled grid schemes for Africa and discussed whether they are a recipe for disaster. Lori Pottinger, Campaigns Director, Africa Programs, International Rivers Network, Berkeley, CA, USA, presented it.

Numerous grand schemes to crisscross Africa with electricity grids are being planned today, with involvement by associations of African governments, foreign donors, the World Bank, and energy companies. Many of these plans rely heavily on new large hydropower projects. NEPAD, the Nile Basin Initiative and the Southern African Power Pool all propose many new large dams, while including in their plans only modest investments in more sustainable energy supply or efficiency measures.

At a time when global warming threatens to make Africa’s rivers even less reliable for economically feasible large hydro projects, and their waters more precious for other uses, the energy industry and governments should be looking to increase Africa’s reliance on less risky forms of energy supply. This was discussed, analyzed, and evaluated.

This presentation used the Nile Basin as a case study to discuss the problems with grid schemes that rely heavily on large hydro, and the reasons that good energy planning is imperative for Africa.

Lori Pottinger has worked for International Rivers Network since 1995. She is the editor of IRN's bimonthly publication *World Rivers Review*, and the director for IRN's Africa programs. She has worked particularly closely on the massive Lesotho Highlands Water Project, the proposed Epupa Dam in Namibia, the Bujagali Dam proposed for the Nile in Uganda and others. Ms. Pottinger has a bachelor's degree in journalism from San Francisco State University, and a master's degree in landscape architecture from the University of California, Berkeley.

9). The ninth presentation was entitled: The Energy Challenge and was prepared by Moshin Chen, Professor Emeritus**,** Director Energy Systems Research Center, University of Texas at Arlington, TX, USA. Tom Hammons and Bai Blyden presented it.

The electric utility industry is undergoing a time of uncertainty as the deregulation process develops. This phenomenon not only applies to the United States but to the entire world. After more than a decade, questionable restructuring results in countries such as the United Kingdom, New Zealand or Argentina (to name some of the pioneering cases), give a clear indication of the difficulties and risks involved in the process. Moreover some serious events have taken place in USA since the inception of the energy reform; notably the California crises in the Summer of 2000, which included the bankruptcy of major traditional utilities, followed by the Enron debacle a year later with its very unfavorable impact on the rest of the industry. In the presentation, this was discussed and critically analyzed.

Mo-Shing CHEN is Professor of Electrical Engineering, and Director, Energy Systems Research Center, T University of Texas at Arlington, USA. His educational qualifications include a Ph.D. in Electrical Engineering, University of Texas at Austin, 1962. His fields of authority include analysis (including real-time) in transmission, distribution, generation, and electrical service. In consulting, his 21 consultancies include Consolidated Edison Company of New York, Inc., New York, New York; U.S. Bureau of Reclamation, Denver, Colorado; Texas Electric Service Company, Dallas, Texas; Taiwan Power Company, Taipei, Taiwan, Republic of China; Korea Electric Power Corporation, Seoul, Korea; Electric Power Research Institute, Beijing, China; Nanjing Automation Research Institute, Nanjing, China; and Central Electrical Power Research Institute of Japan.

He has 25 Honors including: Edison Electric Institute's First Power Engineering Educator Award, June 1976; Fellow, Institute of Electric and Electronics Engineers, 1978, Chinese Institute of Engineering, Achievement Award, 1978; IEEE Centennial Medal Award, 1984; Honorary Visiting Professor, Tsing Hua University, Beijing, China, 1990; Honorary Consulting Professor, Xi'an Jiaotong University, Xi'an, China 1989; and Honorary Doctor of Electrical Engineering, University of Nuevo Leon, Mexico, 1997.

10). The penultimate presentation was entitled: Impact of Privatization and Deregulation on Infrastructure Development in Africa. Raymond Johnson, Energy Consultant, EnergyCon, Inc., Altadena, CA, USA presented it

In an effort to increase the amount of investment funds available for infrastructure development, many Western governments and funding agencies such as the World Bank have been encouraging African countries to liberalize their regulatory policies. The theory is that privatization and deregulation of capital-intensive sectors such as energy will attract investment funds from private sources that will augment the resources available for infrastructure development in Africa. This was discussed.

Raymond Johnson is the founder of EnergyCon, Inc, an international engineering consulting company. He is also an Energy Consultant with BBRM Investments, LLC, USA. He consulted on wholesale energy markets for various energy consulting and software companies, private power marketers and state and federal government energy agencies. Raymond Johnson has a Master of Arts degree in Electrical Sciences from Trinity College, Cambridge University, a Ph.D. in Electrical Engineering from Imperial College, London University and executive MBAs from the University of California, Berkeley and Columbia University, New York.

11). The final presentation discussed the status of international interconnections and electricity deregulation in Africa and gave an overview of the current status in southern Africa. It was presented by Jan A de Kock, Potchefstroom University, South Africa.

The Southern African power system is in a state of flux. The grid is expanding and more interconnections are being made. However, vastness of the area and the low power consumption density in most African countries makes operation of the interconnection difficult. Some of the utilities are also being privatized to improve their financial and system performance.

The situation in the Southern African Power Pool (SAPP) is steadily improving and a short-term energy market has been established between the various utilities. Key projects are also in the pipeline to improve the generation and transmission capabilities within the SAPP. This was discussed.

Jan A de Kock holds a BEng (1985), MEng (1987) and PhD (1991) in Electrical Engineering from Stellenbosch University in South Africa. At present he is a Professor in Electrical Engineering at the Potchefstroom University for CHE in South Africa. His academic and consulting interests include power system dynamic performance, power quality, protection performance and optimization studies, improvements of generator dynamic response, induction and synchronous machine transient performance, and high speed bus transfer systems. He is the author of a number of papers and the co-author of a book.

The final EXTENDED PANEL SESSION SUMMARIES follow

Rec'd June 9, 2004

1. TOWARDS DEVELOPING A COMPETITIVE MARKET FOR REGIONAL ELECTRICITY CROSS BORDER TRADING: THE CASE OF THE SOUTHERN AFRICAN POWER POOL (SAPP). Paper 04GM0755

P Naidoo, L Musaba, W Ballet, A Chicova, SAPP Competitive Electricity Markets Working Group

Abstract

Regional electricity cross border trading is governed by fixed co-operative bilateral agreements; generally of a long-term duration. The fixed power purchase agreements provide for the assurance of security of supply but are not flexible to accommodate varying demand profiles and varying prices. The pricing of electrical energy defers for periods of peak and off peak consumption. To explore further the benefits thereof, the sourcing and scheduling of electrical energy closer to the time of dispatch was investigated. Research has shown that competitive bidding is one option for sourcing and securing supplies closer to real time dispatch. Using the experiences of the Southern African Power Pool (SAPP) as a case study, a competitive market framework for cross border electrical energy trading was developed. In April 2001, the market commenced trading with a few participants. With increasing participants and market confidence, the results of the first two years show that the model is robust and is a recommended framework for cross border short term electrical energy trading. The short-term energy market; designed to be day ahead, compliments the bilateral market and provides another technique for the pricing of electrical energy. With the addition of real time communications and energy management systems, the spot market for competitive bidding is the next step.
***Keywords*:** Cross Border Trading, Pricing of Electrical Energy, Competitive Markets.

1.1 Introduction

The trading of electrical energy between neighbouring countries is synonymous with economic development and the enhancement of the quality of societal life. Based on intergovernmental agreements, the general arrangement is for the national utilities to engage into long term bilateral contracts for the sourcing and consumption of electrical energy. The intergovernmental agreements and the bilateral contracts form the foundation for cross border electrical energy trading.

The routine activities that follow include scheduling, settlements and the monitoring of quality of supply. Further on, based on events, detailed investigations are conducted into inadvertent energy flows and major power system faults and disturbances.

For the bi-lateral contracts, the pricing of electrical energy is negotiated and the outcome is generally based on the classical economics of supply and demand. At times of peak consumption, the price for electrical energy is generally higher. At times of off peak consumption, the prices are generally lower. Comparison of the difference in rates for peak and off peak consumption for four countries in the Southern Africa market is given in Table-1.

The off peak tariff in most countries is approximately 40 % of the peak tariff. This difference promotes the new business opportunity. Hence, we introduce a new process for pricing of electrical energy in the short term.

Table-1: **Difference in Rates for Peak and Off Peak consumption for domestic customers with a monthly average consumption of 450 kWh in four countries in the Southern African Electrical Energy Market.**

Country	*Peak to Off Peak Differences in rates*
South Africa	Peak: 0.034 US c/kWh Off-Peak: 0.014 US c /kWh Difference: 0.020 US c /kWh
Zimbabwe	Peak: 0.051 US c /kWh Off-Peak 0.020 US c /kWh Difference: 0.031 US c /kWh
Botswana	Peak: 0.04 US c /kWh Off-Peak: 0.016 US c /kWh Difference: 0.024 US c /kWh
Namibia	Peak: 0.033 US c /kWh Off-Peak: 0.013 US c /kWh Difference: 0.020 US c /kWh

The time-based differentiation in pricing arises from the physical constraint in that the produced electrical energy must be instantly consumed. The storage of electrical energy is not practical. Energy banking and pumped storage schemes are the exceptions for electrical energy storage for a very small percentage of the total electricity generated.

1.2 Case Study for Southern African Power Pool

The Southern African Power Pool (SAPP) is a regional body that was formed in 1995 through a Southern African Development Community (SADC) treaty to optimise the use of available energy resources in the region and support one another during emergencies. The power pool, whose Co-ordination Centre is located in Harare, comprises of twelve SADC member countries represented by their respective electric power utilities.

SAPP is managed by the decision-making that occurs in the hierarchical structured committees illustrated in Figure-1. Reporting to the Energy Ministers of SADC is the Executive Committee that is composed of the Chief Executives of the participating utilities. Reporting to the Executive is the Management Committee, which is composed of senior managers from the transmission system operations and energy trading divisions of each utility.

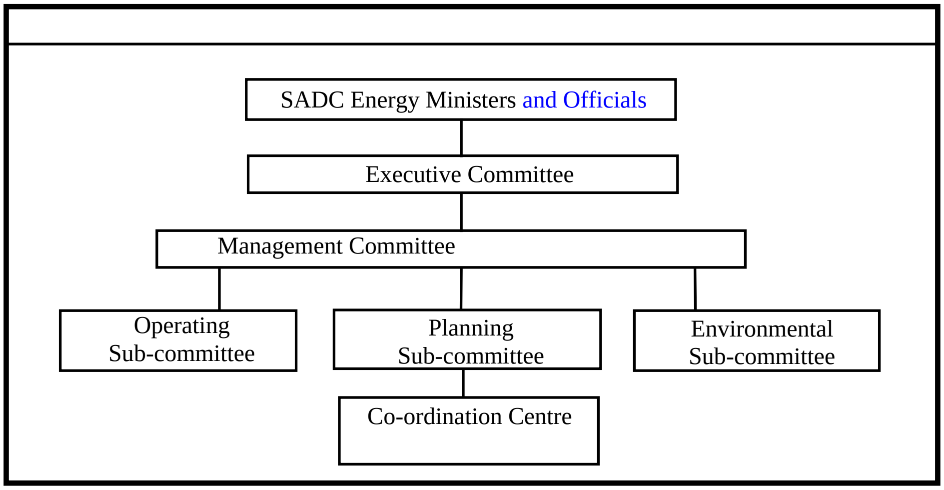

Figure 1. SAPP Structure

The Management Committee collates the proceedings of the sub-committees of Operating, Planning and Environmental, summarizes the proposals and recommendations and presents bi-annually the report to the Executive Committee. In the SAPP proceedings of 1999, the recommendation from the Operating Sub-Committee to introduce a competitive market for short term energy trading was submitted and approved. This paper will discuss in depth the design and rules of the short-term energy market. The results of more than two years of trading activity will be analysed for recommended conclusions.

1.3 Design of the Short Term Energy Market

The goal of standard market design is to establish an efficient and robustly competitive wholesale electricity marketplace for the benefit of consumers [1]. This could be done through the development of consistent market mechanisms and efficient price signals for the procurement and reliable transmission of electricity combined with the assurance of fair and open access to the transmission system.

For the Short-Term Energy Market (STEM) design, the following criteria was submitted as input:

i.) *Transmission rights* - Long and short-term bilateral contracts between participants have priority over STEM contracts for transmission on the SAPP interconnectors. All the STEM contracts are subject to the transfer constraints as verified by the SAPP Co-ordination Centre.

ii.) *Security requirements* - Participants are required to lodge sufficient security with the Co-ordination Centre before trading commences and separate security is required for each energy contract.

iii.) *Settlement* - Participants have the full obligation to pay for the energy traded and the associated energy costs. The settlement amounts are based on the invoices and are payable into the Co-ordination Centre's clearing account. It is the responsibility of the Participants (buyers) to ensure that sufficient funds are paid into the clearing account for the Co-ordination Centre to effect payment to the respective Participants (sellers).

iv.) *Currency of trade* - The choice of currency is either the United States American Dollar or the South Africa Rand dependent on the agreement between the buyer and the seller.

v.) *Allocation method* - The allocation of available quantities based on the available transmission capability is by fair competitive bidding with equal sharing of available quantities to the buyers.

vi.) *Firm contracts* - Once contracted, the quantities and the prices are firm and fixed. There are currently three energy contracts that have been promoted in the STEM as follows; monthly, weekly and daily contracts.

To commence the design process, three working groups were tasked to detail the parameters for settlements (Treasury Working Group), the parameters for trading (Trading Working Group) and the parameters of governance (Legal Working Group). The working groups were composed of specialists from the participating utilities. The work was conducted over a period of one year.

The results of the working group is summarized and given in Table-2.

Table 2. Summary of Design Features for the Short Term Energy Market.

Treasury Working Group	• Currency of trade. • Security of Payments • Clearing Institution & location • Settlement process
Trading Working Group	• Trading Platform • Wheeling Charges • Trading Rules • Daily Scheduling Procedures • Market Structure
Legal Working Group	• Governance documents • Regulatory Rules • Agreements

The trading platform for the new competitive short-term market was designed locally. The platform employs a matrix for the solution of simultaneous linear equations that were formulated as follows.

Assume that ***P*** *MW* of power is on offer and that there are altogether ***n*** offers and ***m*** bids. Let us also assume that a given bidder ***j*** receives power from a given seller ***i*** and that this power is P_{ij} as illustrated in Table-3.

For ***n*** offers, it can be shown that

$$
\left.\begin{aligned}
&P_{11} + P_{12} + P_{13} + P_{14} + \dots + P_{1m} = \sum_{j=1}^{m} P_{1j} \\
&P_{21} + P_{22} + P_{23} + P_{24} + \dots + P_{2m} = \sum_{j=1}^{m} P_{2j} \\
&. \\
&. \\
&. \\
&P_{n1} + P_{n2} + P_{n3} + P_{n4} + \dots + P_{nm} = \sum_{j=1}^{m} P_{nj}
\end{aligned}\right\} \quad (1.0)
$$

Table 3. Power Allocation Table

		1	2	3	4	
		BIDS				
	OFFERS	*NAM*	*SEB*	*LEC*	*ZESA*	*TOTAL*
1	*SNEL*	P_{11}	P_{12}	P_{13}	P_{14}	$\sum_{1}^{4} P_{1j}$
2	*ZESCO*	P_{21}	P_{22}	P_{23}	P_{24}	$\sum_{1}^{4} P_{2j}$
3	*EDM*	P_{31}	P_{32}	P_{33}	P_{34}	$\sum_{1}^{4} P_{3j}$
4	*ESKOM*	P_{41}	P_{42}	P_{43}	P_{44}	$\sum_{1}^{4} P_{4j}$
	TOTAL	$\sum_{1}^{4} P_{i1}$	$\sum_{1}^{4} P_{i2}$	$\sum_{1}^{4} P_{i3}$	$\sum_{1}^{4} P_{i4}$	$\sum_{1}^{4} P_{ij}$

Similarly for ***m*** *bids* we get,

$$
\left.\begin{aligned}
&P_{11} + P_{21} + P_{31} + P_{41} + \dots + P_{n1} = \sum_{i=1}^{n} P_{i1} \\
&P_{12} + P_{22} + P_{32} + P_{42} + \dots + P_{n2} = \sum_{i=1}^{n} P_{i2} \\
&. \\
&. \\
&. \\
&P_{1m} + P_{2m} + P_{3m} + P_{4m} + \dots + P_{nm} = \sum_{i=1}^{n} P_{im}
\end{aligned}\right\} \quad (2.0)
$$

If *OFFER_POWER [i]* is the maximum power offered by ***seller i*** and *BID_POWER [j]* is the maximum power requested by ***bidder j***, then the selling and buying conditions must satisfy the following Equations (3.0) and (4.0) respectively, for offers and bids.

$$\left.\begin{array}{l}\sum_{i=1}^{m} P_{1i} \leq OFFER\_POWER\ [1] \\ \sum_{i=1}^{m} P_{2i} \leq OFFER\_POWER\ [2] \\ . \\ . \\ . \\ \sum_{i=1}^{m} P_{ni} \leq OFFER\_POWER\ [n]\end{array}\right\} \quad (3.0)$$

$$\left.\begin{array}{l}\sum_{j=1}^{n} P_{j1} \leq BID\_POWER\ [1] \\ \sum_{j=1}^{n} P_{j2} \leq BID\_POWER\ [2] \\ . \\ . \\ . \\ \sum_{j=1}^{n} P_{jm} \leq BID\_POWER\ [m]\end{array}\right\} \quad (4.0)$$

The value of the power P_{ij} at other positions can easily be evaluated from the *qualification criterion*. If the offer price from the *seller I* is more than the bidder price by the *bidder j*, then if follows that $P_{ij} = 0$.

It was initially stated that the cheaper power has to be shared first equally amongst all the qualified bidders. Therefore, it follows that the ***cost function*** (i.e. cost per hour) with respect to the bidder must be *minimised* to get the optimal solution for all the offers and bids. The cost function in this case is the product of the price of the offer power by the power allocated to the buyer from the particular seller. The unit of the cost function is therefore *cents per KWh*.

The optimization problem for any given buyer at position ***j*** and for ***n*** sellers can then be stated as follows:

Minimize:

$$Cost\ f = OFFER\_PRICE[1] * P_{1j} + OFFER\_PRICE[2] * P_{2j} + ... + OFFER\_PRICE[n] * P_{nj}$$

Subject to:

1. $P_{ij} = 0$ when Equation (1.0) is not satisfied.
2. Transmission system constraints and other wheeling constraints
3. $\sum_{k=1}^{m} P_{jk} \leq OFFER\_POWER\ [j]$
4. $\sum_{i=1}^{n} P_{ij} \leq BID\_POWER\ [j]$

There are two ways of solving the optimization problem of this nature; *Mathematically* using the well-known linear optimization techniques or using the *market rules* that have been formulated. The method that was finally adopted combined the two approaches. The market rules simplified the task of incorporating system transmission and wheeling constraints.

The proposed algorithm first allocates the power equally to all the successful bidders. If the power allocated is more than what the bidder requested, adjustments are made to the affected bidder. Then the transmission constraints are applied to check for any system violations. If no violation is detected, the solution is accepted. If violation is encountered, the allocated power is adjusted until no violation is observed.

Using the proposed algorithm a computer program called ***STEM Program Manager*** was written to automate and computerize the allocation of offers to successful bidders.

<u>*Example 1*</u>

Assume that there are two offers from BPC and EDM respectively and one bid from ZESA as shown in Table-4.

Table-4
Offers and Bids for the Example

Offers			***Bids***		
Utility	*Power MW*	*Offer Price US c/kWh*	*Utility*	*Power MW*	*Bid Price US c/kWh*
BPC	100	2.5	ZESA	150	3.0
EDM	100	3.0			

Let

P_1 of power be sold by BPC to ZESA at *2.5 cents per kWh*, and
P_2 of power be sold by EDM to ZESA at 3.0 *cents per kWh* respectively.

The problem can then be stated as that of minimising the bidder *cost function (Cf)* subject to the power requirement constraints as follows:

<u>**Minimise:**</u> $Cf = 2.5P_1 + 3.0P_2$
<u>**Subject to:**</u> $P_1 + P_2 \leq 150$
$P_1 \leq 100$ and $P_2 \leq 100$

The power transfer of P_1 and P_2 to ZESA from BPC and EDM respectively, should not cause any part of the transmission system to be overloaded and should be within utility-to-utility inter-connector limits in order to satisfy the transmission system constraints. Note also that in this example there are no wheelers involved.

Table-5 gives a possible combination of P_1 and P_2 that satisfies the cost function under the given constraints.

It is clear from Table-5 that the minimum cost function is 400 cents per hour and occurs when $P_1 = 100MW$ and $P_2 = 50MW$. Thus ZESA gets 100 MW of power from BPC and 50MW from EDM.

If there is more than one bidder, the optimisation procedure given in the example is repeated for each bidder to get the optimum solution.

1.4 Analysis of Trading Results and Market Performance.

- Excess capacity prevails in the regional market, generally during off peak. Electrical energy prices are generally, on average, lower than that for the bilateral market.
- The number of market participants increased from four in the first year to eight as at May 203.
- The average tariff of energy traded is in the range from 0.3 to 0.6 US c/kWh. The highest matched price was 1.45 US c /kWh.
- The offer prices tend to increase as we approach the cold winter months when the SAPP regional peak demand occurs. This behaviour concurs with the economics of supply and demand.
- Transmission availability determines successfulness of trade. Transmission congestion mainly on the cross border tie lines constrains trade.
- Opportunity for trading short term is available. The highest monthly revenue was equivalent to USD 380, 000.00. The figure is projected to increase.

1.5 Summary of Results

1.5.1 Day ahead market

Table-5

Possible Combinations of P_1 and P_2

P_1	0	2	4	*5*	*6*	*75*	*8*	*10*	140	150
P_2	150	13	11	*10*	*9*	*75*	*7*	*5*	10	0
$P_1 + P_2$	150	15	15	*15*	*15*	*150*	*15*	*15*	150	150
$Cf = 2.5P_1 + 3.0P$	450	44	43	*42*	*42*	*412.*	*41*	***40***	390	375
	$P_1 + P_2 \leq 150$ Satisfie $P_2 \leq 100$ **NOT** satisfie Region NOT Permissibl			$P_1 + P_2 \leq 150$ Satisfied. $P_2 \leq 100$ Satisfied $P_1 \leq 100$ Satisfied. Permissible Region.					$P_1 + P_2 \leq 15$ Satisfied. $P_1 \leq 100$ Is **N** satisfied. Regi **NOT** permissi	

Figure 2 shows the supply and demand situation for the day-ahead market. At the start of the market, the supply was much higher than the demand, until a year after the market has started was when the demand became higher than the supply.

Figure 3 shows the energy traded together with the associated cost of energy. The energy traded on the STEMK market has been increasing on a monthly basis. The main constraint to the trading has been the transfer tie-line limits between the northern and southern utilities

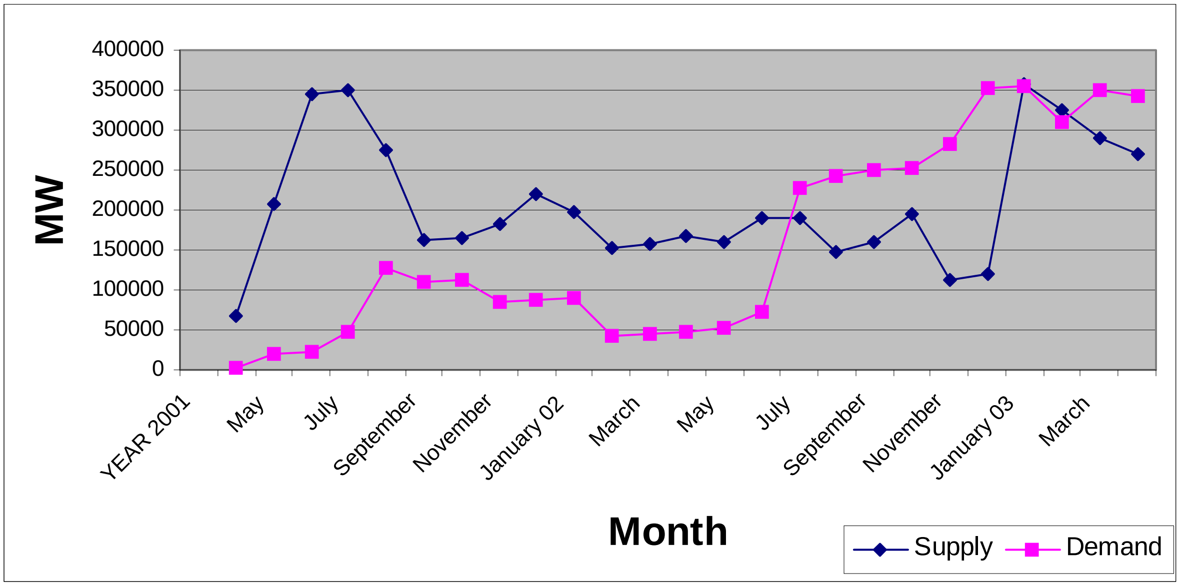

Figure-2. Supply and Demand

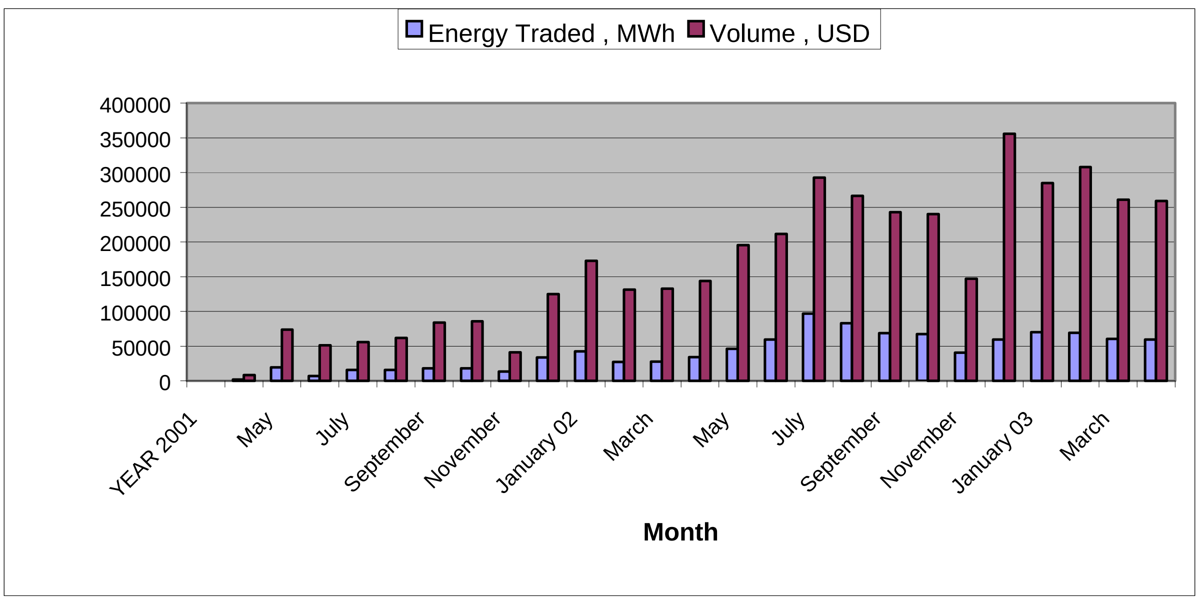

Figure-3. Energy and Volume Traded

1.5.2 Post STEM Energy Market

The Post STEM energy contracts are concluded outside of the STEM market between participants through bilateral negotiations. Unallocated STEM bids and offers are published on the Internet and these offers and bids are available for hourly trading on the trading day.

This market started in December 2001 and is now about ten percent of the energy traded on the STEM. A higher tariff than the STEM is agreed and trading takes place the next day.

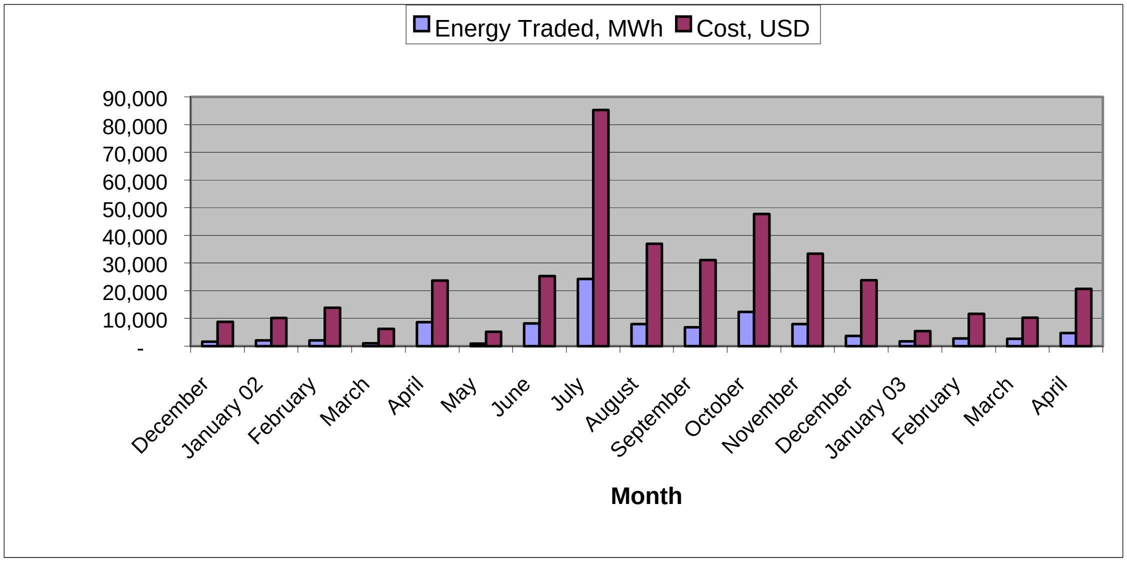

Figure 4. Energy and Volume Traded in the Post STEM Energy Market

1.6 Conclusion

At the 1995 Financial Times World Electricity Conference held in London [2], Professor John Cheshire of the University of Sussex, noted in his opening address that increasing interdependence of regional economies and with improved transmission technology, cross border trading will emerge and provide new opportunities for cost reduction and lower prices to customers. At the same conference, Esser-Scherbeck [2] reported that an open and liberalized German market promoted an increase in competition amongst buyers and sellers and an increase in short term energy trading. The SAPP experience to date concurs with that of Chesshire and Esser-Scherbeck.

The outlook for the future regional market includes an increase in trend for deregulation and liberalization with private equity participation. Spalding-Fecher in contribution to developing South Africa's Energy Policy promotes diversity of source as a strategy to secure national energy supply [3]. Other countries have similar strategies and the net result will be an increase in interconnectivity and cross border trading. With policy established, the ever-increasing customer pressure for environmentally friendly competitively priced electricity will stimulate and energize the market. Existing capacities will be challenged from the new lower cost renewable energy entrants and market forces will grow in dominance. The large untapped run of the river projects is now emerging as potential new sources of regional energy; for example the Inga development in the Democratic Republic of Congo. The economic renaissance of the continent gathers momentum; supported by the policies and practices of NEPAD, the New Partnership in Africa's Development.

1.7 References

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[2] Financial Times Conferences, 1995. World Electricity Conference: London (UK), Pearson Professional Publication, London, UK.

[3] Spalding-Fecher, R., 2002. Energy and Energy Policies in South Africa: An Overview. NER Quarterly Journal. Issue 1,2002,p 1-18.

Biography

Pathmanathan Naidoo
Current Designation: Senior General Manager – Transmission Division, Eskom, South Africa

Background

Mr. Naidoo is a registered professional engineer, a graduate in Electrical Engineering from the University of Durban Westville in South Africa and a postgraduate with an MBA from Stamford University in the USA. Presently, Mr. Naidoo is an engineering doctorate student with the University of Warwick in Coventry, United Kingdom.

Work History: Nineteen years ago, Mr. Naidoo joined Eskom as an engineer in training. In 1988 he was registered as a professional engineer and was appointed the Distribution Regional Planning and Design Engineer. In 1989 he was appointed Senior Engineer to lead a newly created portfolio of Quality of Supply in the Regional Engineering Department. In, 1990 he was promoted to Principle Engineer of Regional Engineering. In 1991 he was transferred to the newly created national group of Transmission and later appointed as Chief Engineer in the Operating and Maintenance Division. Here his work covered the hands on operating and maintenance of the 22 000 km Eskom National Grid having voltages 765 kV, principally 400 kV and 275 kV. In 1995, he was promoted to Senior Manager in charge of the Kwa -Zulu Natal and Free State Area of the Eskom National Grid. Some of the key customers included the deep underground gold mines in Welkom, the major South African cities of Durban and Bloemfontein and the BHP Billiton aluminum smelters and open arc titanium furnaces in Richards Bay. In 1998 he was appointed to the Transmission Group Executive Management and the Eskom Management Board Operations Committee. The accountability was for South and Southern Africa's Electricity Transport and Delivery; including the management of System Operations, the Eskom Power Pool Operations, Eskom's National Control and the Southern African Power Pool Operations. In 1999, Mr. Naidoo was promoted to Senior General Manager of Eskom's Transmission Division. In 2001, Energy Trading was added to his accountabilities. In 2002, he was appointed as Technical Director on the board of Motraco, the Mozambique Transmission Company, a joint venture initiative between South Africa, Mozambique and Swaziland. In 2003, Mr. Naidoo participated in the Chief Executive initiated working group for the planning for the Western Power Corridor; a joint venture between Eskom of South Africa, BPC of Botswana, Nampower of Namibia, ENE of Angola and SNEL of the Democratic Republic of Congo; focused on the development of 3500 MW of run of the river hydro generation and the transmission of the energy on two HVDC circuits over 3000 km.

In 1994, Mr. Naidoo received the South African Institute of Electrical Engineers young achievers award.

Current Work Assignments: Mr. Naidoo is a member of the Transmission Divisional Board of Eskom. His accountabilities include:

- The establishment a new direct regulatory interface between Transmission and the National Electricity Regulator as part of forward planning for the establishment of an independent Transmission Company in the proposed open competitive market in South Africa.

- The establishment of the South African Power Exchange, initially as a subsidiary of Eskom Holdings Limited and later as an independent state owned entity.
- The establishment of a Transmission Center of Excellence in Electrical Engineering; integrated with local and international universities and with the workings of Cigre.
- The integrated management and commissioning of large scale capital projects on the Eskom National Grid such as additional capacity and extension of Eskom's 765kV Alpha – Beta scheme and extensions and additional capacity for the second Mozal aluminum smelter in Maputo, Mozambique. Specifically for 765 kV, Eskom is on consultancy contract to Powergrid of India and in discussion with State Power of China for consultancy review of their Go West 750kV Project with National Thermal Power Corporation for the Sipat 765 kV consultancy tender; and
- Technical studies leader of the Westcor Working Group, a five country Chief Executive led project for the run of the river hydro electricity generation at Inga in the Democratic Republic of Congo; 3500 MW with two 3000 km HVDC, 2 GW, 500 – 600 kV multi-terminal schemes to terminate on the South African National Grid.

Mr. Naidoo is married, has two sons and when not at work he enjoys sports, gym and participating in music and drama. He is a keen D-I-Y enthusiast and is the most relaxed when working at home and in the garden.

Lawrence Musaba is the Co-ordination Center Manager for the Southern African Power Pool. He is an IEE Member and Chartered Engineer. His E-mail Address is Musaba@sapp.co.zw

William Balet is the Senior Advisor to SAPP. His E-mail Address is wbalet@sapp.co.zw

Alison Chikova is the SAPP Supervisor System Studies. He is an IEE Member and Chartered Engineer. His E-mail Address is Alison.Chikova@sapp.co.zw

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2 STATUS OF GULF CO-OPERATION COUNCIL (GCC) ELECTRICITY GRID SYSTEM INTERCONNECTION

A. Majeed H A Karim[1], N.H Al Maskati[2], S. Sud[3]

Abstract: This paper reviews the status of the Gulf Co-Operation Council Electricity Grid System Interconnections

Keywords: Interconnection, grid systems, HVDC back-to-back converter, technical feasibility, Financial feasibility, finance options

Introduction

Recognizing the benefits of interconnection of their power grids, the six Arab states of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) had a study carried out in 1990 to define an Interconnection Project and to determine its feasibility. The study recommended an AC interconnection of the 50 Hz systems of Kuwait, Bahrain, Qatar, UAE and Oman with a back-to-back HVDC interconnection to the 60 Hz Saudi Arabian system. The study concluded that the recommended Interconnection Project for the GCC countries was technically feasible as well as economically and financially viable.

As recommended in the 1990 study, the Gulf Co-operation Council Interconnection Authority (GCCIA) has been established and given the mandate to proceed towards implementation of the Interconnection Project.

In light of the time that has elapsed since the 1990 study and in view of the evolution of the power sectors in the GCC countries, it was decided in 2002 to update the studies that had been carried out and to re-confirm the feasibility of the Interconnection Project, carry out a Market study, prepare a plan for financing of the Project, develop the Agreements that have to be reached between the different countries, and prepare an implementation strategy.

Evolution of the Power Sectors in the GCC countries

In 1990 all the power utilities were government owned and vertically integrated. Governments in the region have already embraced the need and accepted the benefits of private sector participation in the power sector. Since then, legislation has been passed in Oman, U.A.E., Qatar and Saudi Arabia allowing the construction and operation of private power (and desalination) plants. Bahrain is

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expected to embrace private sector participation in the power sector shortly. Most of the GCC countries are in the process of unbundling their power systems into generation, transmission and distribution entities. The presence of an Interconnection between the GCC countries will in addition to enabling sharing of reserves, thus reducing the generation requirements in each country, provide the opportunity for trading electricity between the member countries as well as eventually trading outside the GCC.

Demand Growth in the GCC Countries

The demand in the GCC countries as shown in the Table 1 is expected to grow from 32,747 MW to almost 94,000 MW over the next 25 years.

Table 1: Demand Growth up to 2028

Year	Kuwait MW	Saudi Arabia* MW	Bahrain MW	Qatar MW	UAE MW	Oman MW	Total MW
2003	7685	9910	1547	2308	9137	2160	32747
2008	10284	13945	2070	3184	12780	2662	44925
2010	11555	14745	2325	3387	14383	2824	49219
2028	27017	23210	4989	4649	29358	4558	93781

* The Saudi Arabia demand only includes the demand supplied by the SEC-ERB (i.e. the load in the Eastern Region and the firm exports to the Central Region)

The Interconnection Project

The feasibility study recommended that the grid system interconnection between the GCC states is feasible from all technical and financial considerations and recommended the project be carried out in three phases as shown diagrammatically in Figure 1.

- Phase I: Interconnection of the Northern Systems (Kuwait, Saudi Arabia, Bahrain and Qatar) in 2008.
- Phase II: The internal interconnection of the Southern Systems (UAE and Oman) to form the UAE National Grid and the Oman Northern Grid.
- Phase III: Interconnection of the Northern and Southern Systems in 2010.

ınection

Figure 1. Approximate Rout and Layout of the GCC Interconnection

The Interconnection Project consists of the following principal elements:

Phase I:

- A double-circuit 400 kV, 50 Hz line from Al Zour (Kuwait) to Ghunan (Saudi Arabia) with an intermediate connection at Fadhili (Saudi Arabia) and associated substations.
- A back-to back HVDC interconnection to the Saudi Arabia 380 kV, 60 Hz, system at Fadhili.
- A double circuit 400 kV comprising overhead lines and submarine link from Ghunan to Al Jasra (Bahrain) and associated substations.
- A double circuit 400 kV line from Ghunan to Salwa (Saudi Arabia) and associated substations.
- A double circuit 400 kV line from Salwa to Doha South (Qatar) and associated substations.
- A Control Center located at Ghunan.

Phase III:

- A double circuit 400 kV line from Salwa to Shuwaihat (UAE) and associated substations.
- A double circuit 220 kV line from Al Ouhah (UAE) to Al Wasset (Oman) and associated substations.
- A single circuit 220 kV line from Al Ouhah (UAE) to Al Wasset (Oman) and associated substations.

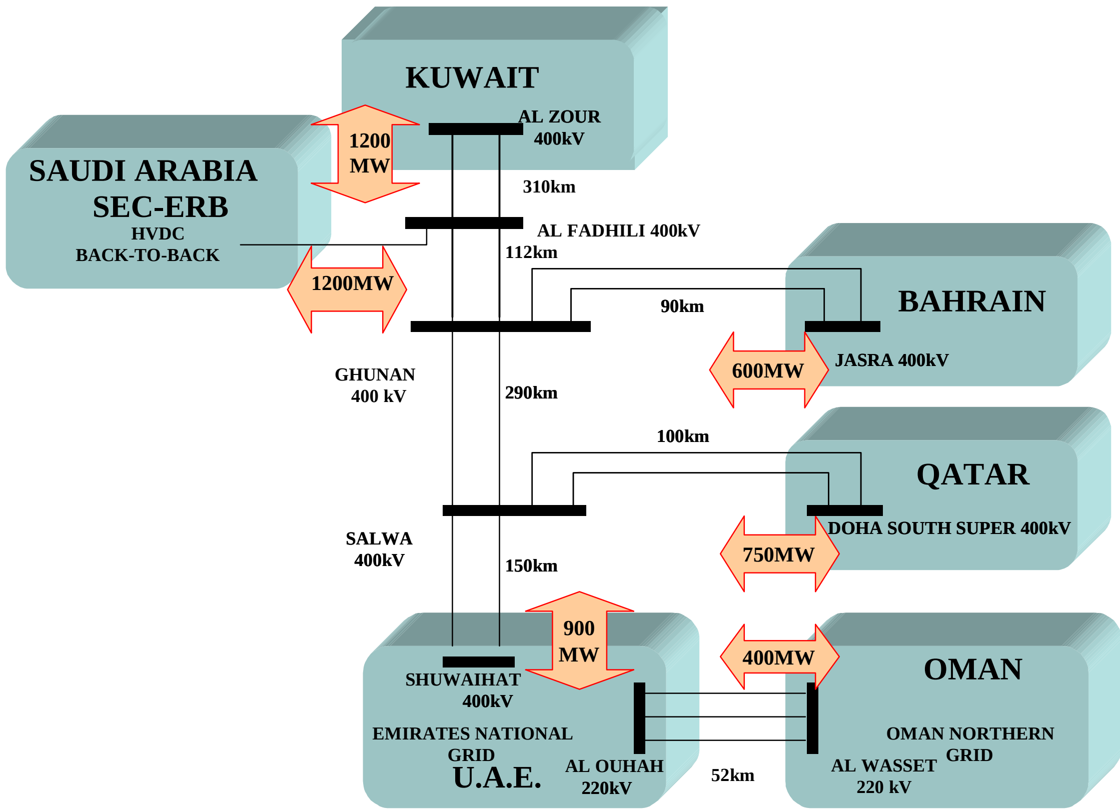

Figure 2: Conceptual Diagram of the Interconnection System

The capacity of the Interconnection to each of the countries is given in Table 2:

Table 2: Size of Interconnection to each GCC State

System	Size (MW)
Kuwait	1200
Saudi Arabia	1200
Bahrain	600
Qatar	750
UAE	900
Oman	400

Cost of the Interconnection Project

The estimated cost of the Interconnection Project based on economic conditions of 2003 for Phase I and Phase III is $US 1189 million and $US 137 million respectively.

Benefits of the Interconnection Project

The principal benefits that can be achieved through Interconnection are as follows:

- Interconnections result in the requirement for a lower installed capacity in each of the systems (due to reserve sharing) while still supplying the load with the same (or better) level of reliability.
- Interconnections can permit larger and more efficient generating units to be installed on the individual systems.
- Interconnections enable systems to share operating (spinning) reserves so that each system can carry less spinning reserve.
- Interconnections enable interchange of energy between systems resulting in a lowering of total operating costs.
- Interconnections permit assistance from neighboring systems to cope with unforeseen construction delays and unexpected load growth.
- Interconnections permit emergency assistance between systems to mitigate the effects of unforeseen contingencies such as catastrophic multiple outages.

In the present study the benefits due to reduced generation requirements as a result of reserve sharing were quantified. In addition, the opportunity for power trading between the countries was also assessed.

The principal benefits due to the interconnection arise from the sharing of reserves between the systems and the consequential reduction in the installed generating capacity and associated operating and maintenance costs in the GCC countries. The capacity benefits to 2028 for Phase I are shown in the Table 3 below:

Table 3: Generation Capacity Reduction Benefit for Phase 1 Countries

Country	**Load (MW)**	**Total Installed Capacity (MW)**		**Cumulative Benefit (MW)**	**Reserve (MW)**	
		Isolated	Interconnected		Isolated	Interconnected
Kuwait	27017	30397	29066	1331	3380	2049
Saudi Arabia	23210	26361	24752	1609	3151	1542
Bahrain	4989	5782	5494	288	793	505
Qatar	4649	5427	5060	367	778	411
Total	59865	67967	64372	3595	8102	4507

It was also found that given the high differential between the price of gas and the price of crude oil (a ratio of almost one to four) there is a significant potential for economy interchange between the countries. However, there is a lot of uncertainty in whether or not such savings can be counted on towards the economic justification of the Project. Nevertheless, the studies showed that there is an opportunity to trade and for the countries to realize substantial benefits.

Economic Evaluation

The economic evaluation of the Project showed that the benefit to cost ratio for Phase I of the Project is of the order of 1.5 and that the pay back period for the investment is less than four years. Given the small incremental cost of Phase III it is evident that implementation of Phase III would further improve the attractiveness of the Project. Thus the analysis has re-confirmed the economic viability of the Project.

Sharing of the Costs of the Interconnection Project

It was agreed amongst the countries to share the costs of the Interconnection in proportion to the reserve capacity savings. Considering the time value of money and that the capacity savings occur at different points of time, it was agreed to share the costs in proportion to the present value of the capacity savings.

Financing Options for the Project

The financial analysis has re-confirmed the financial feasibility of the Project.

The various options of financing the total cost (capital and operational) of the project are being considered in detail in a separate study carried out by Gulf Investment Corporation (GIC). The finance of the project can be partially or wholly provided from loans or with participation by the private sector, with or without contribution by the governments.

The options of financing the project which was considered in the 1997 feasibility studies were five options as given in the Table 4 below. The first and second option is based on full (100%) ownership of the project by the government, in which case the governments will be responsible for all costs associated with the project.

The third option considers full ownership by private sector. The last two options considers joint with different percentage participation and ownership between governments and private sector.

Table 4: Financing Options Considered

Finance Options	Ownership		Sources of Finance		
			Capital		
	Government	Private sector	Government	Private sector	Loans
1	100 %	-	100 %	-	-
2	100 %	-	35 %	-	65 %
3	-	100 %	-	35 %	65 %
4	50%	50%	17.5 %	17.5 %	65 %
5	50%	50%	25 %	25 %	50 %

There were various important issues when considering the finance options for the project:

- Government risks
- Enhanced efficiency of the private sector to carry out the project when compared to the government

- Cost of the provision of the finance by the government

The GCCIA was set up as per the second option in which the government will be responsible to take 35 % of the cost of the project with the remaining 65 % provided from loans.

Next Steps

An implementation strategy is being developed.

Relevant agreements are being drafted up to confirm the commitment of each of the countries to the Project.

An information memorandum is being prepared to solicit financing for the Project.

Conclusions

The present studies have re-confirmed the technical feasibility, and the economic and financial viability of the Project.

Steps are now being made to take the Project to market and work towards its implementation.

A Majeed H A Karim is a chartered Electrical Engineer and a Fellow of the IEE, UK. He is also a Fellow of the Bahrain Society of Engineers, Bahrain. He obtained his PhD from the University of Bradford, West Yorkshire, UK in 1986 in Power Engineering and has a Masters Degree in Power Systems from UMIST and Bradford. He is presently Advisor to the Undersecretary of the Ministry of Electricity and Water. He had a prime role in the Gulf Cooperation Council (GCC) interconnection over the past ten years and particularly during the phase of setting up the legal and technical structure of the GCC interconnection structure of the GCC Interconnection Authority (GCCIA). He is presently the secretary to the Board of Directors and provides active advise to the executive management of the GCCIA. He is a member of the Committee for the Interconnected Arab Networks (CIAN).

Nabeel Al-Maskati is the Assistant Undersecretary for Planning and Projects at the Ministry of Electricity and Water in the Kingdom of Bahrain and the Vice Chairman of the Gulf Cooperation Council Interconnection Authority. He is an Electrical Engineer graduated in 1975 with Bachelor in Engineering from the American University of Beirut in Lebanon and holds a PhD in Electrical Engineering from the University of Texas at Austin 1978. His field specialization is computer application in Power System Planning and Operation. He is a Senior Member of IEEE, life member of the Bahrain Society of Engineers, member of the Economic Development Institute of the World Bank and the Vice Chairman of the Gulf Cooperation Council Interconnection Authority.

Satish Sud is Vice President of Power Systems in the Energy Division of SNC Lavalin. He is an electrical engineer with over 34 years of experience. and is responsible for the development and management of the Power Systems Group which undertakes electrical transmission and distribution projects, electrical system and energy studies, master plans, power sector reform and restructuring studies, and economic and financial studies. He has directed numerous electrical generation, transmission planning and system design studies, both in Canada and overseas. He was the project manager for the planning studies to determine the techno-economic feasibility of various interconnection projects where both AC and DC alternatives were considered. He has also developed master plans for electrification and national energy plans for several countries.

Some of the countries in which he has participated in planning studies and/or projects are: Canada, USA, Honduras, El Salvador, Nicaragua, Panama, Guyana, Argentina, Peru, Senegal, Mauritania, Mali, Guinea, Ivory Coast, Niger, Nigeria, Benin, Togo, Rwanda, Tanzania, Botswana, Zambia, Zimbabwe, Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates, Oman, Iraq, China, India, Philippines, Indonesia, Vietnam and nine countries of south eastern Europe.

He is a member of the Order of Engineers of Quebec; Institute of Electrical an Electronic Engineers and the Institution of Electrical Engineers (Fellow).

Rec'd 9 Feb 04

(3) ECONOMIC BENEFITS AND STRATEGIC NEW INTERNATIONAL TRANSMISSION IN THE SOUTHERN AFRICAN POWER POOL (SAPP) AND WEST AFRICAN POWER POOL (WAPP)

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Abstract

The Power Pool Development Group at Purdue University has been funded by the United States Agency for International Development (USAID), since 1996, to collaborate with the electricity utilities in 26 countries of Africa in the development of regional long-term capacity expansion planning decision support tools. In the case of the Southern African Power Pool (SAPP), founded in 1995, the Purdue modeling team was in partnership with the SAPP Planning Sub-Committee and member utilities from the 12 countries that constitute the Southern African Development Community (SADC). With the West African Power Pool (WAPP), founded in 2000, the Purdue team is working with the Secretariat of the 14 county member Economic Community of West African States (ECOWAS), and their respective utilities and WAPP coordinating working groups.

The Purdue Long-Term Expansion Model (LTEM), that is used in both the SAPP and WAPP policy planning, is a 20-year planning system for energy and reserve trade between countries, which minimizes the present value of electricity generation costs, and generation/transmission capacity expansion costs subject to reserve and country autonomy constraints on the system.

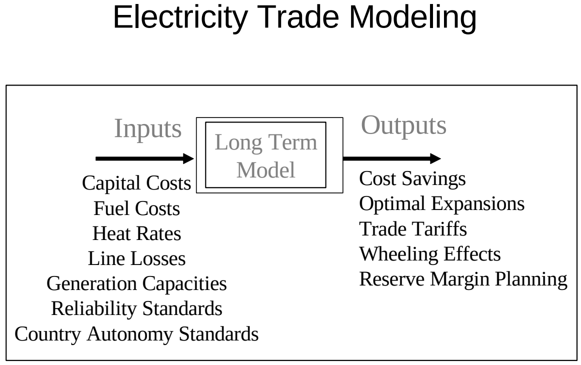
Full technical details of the modeling are available in the literature and modeling results for the SAPP and WAPP are available on the PPDG web site.

Modeling demonstrations consistently indicate the importance of several particular international transmission lines in Africa. In Southern Africa there are the existing lines connecting the Democratic Republic of Congo (DRC) to the Republic of South Africa (RSA), via Zambia and Zimbabwe, as well as the proposed new line to travel down from DRC to RSA through Angola and Namibia, which have major economic impacts on the total costs of operating the Southern African pool. In the case of West Africa the proposed new lines that will connect Nigeria to Benin, and the Zone A of WAPP, as well as the new proposed lines that will connect Guinea and Senegal to produce an integrated Zone B are also strategically vital links in the development of the West African grid.

Demonstrations of the gains from improved trading, for both importers and exporters, in both of these regions of Africa are provided for the Denver meeting, as are the impacts on system needs of the emerging IPP market. Expansions on existing lines and the addition of new proposed lines are indicated as providing the most cost effective investments for improving reliability of supplies across Africa.

Keywords: International electricity trade, Southern African Power Pool SAPP, West African Power Pool WAPP, long-term planning, cost minimization, trading MWh and reserves, capacity expansion, autonomy factors.

Model Formulation



Model Characteristics

How do we modify the model to reflect:

(a) Geography?
(b) Transmission losses/capacities?
(c) Reliability?
(d) Hydro/Thermal characteristics?
(e) Possibility of unmet demands or unmet reserve requirements?
(f) Country Autonomy?
(g) Allowing capacity additions?

Solution to (a) & (b)?

Make the model spatial:
For all countries in the region:
Minimize *{ (cost of regional generation) + (cost of imports) – (revenues from exports over all time periods)}*

Subject to:
• Sum of all country's plus imports (adjusted for line loss) minus exports, meets each country's period demands.
• The capacities of both generation units & transmission lines are not exceeded.

Solution to Reliability, (c)?

Require each country/node to have access to enough capacity to meet peak demand plus a reserve margin, allowing regions to hold reserve capacity for each other:

Minimize over all time periods {(cost of regional generation) + (cost of power imports) + (cost of reserve imports) - (revenues from power exports) - (revenues from reserve exports)}

Subject to:

- Sum of all regional generation plus power imports minus power exports meets regional demands
- Sum of all regional capacities plus capacity imports minus capacity exports meets regional peak demand plus a required reserve margin (15-20% in U.S.)

Solution to Hydro/Thermal Characteristics (d)?

- Recognize that hydro stations have an added seasonal constraint that no more power can be generated than is available in the water stored in the reservoir:

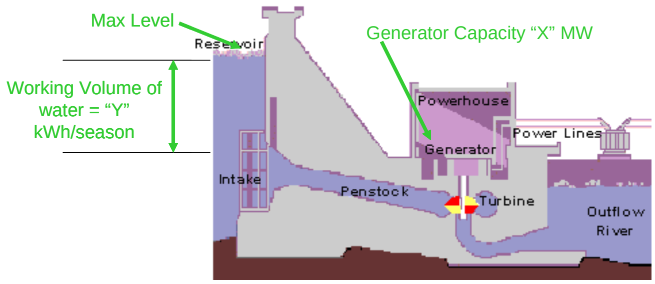


Photo courtesy of http://.ga.water.usgs.gov/edu/hyhowworks.html

Solution to unmet energy demands / unmet reserve margins (e)?

- Unmet Energy: Assume distributed generation available at fixed cost/kWh, or put in own estimate of consumer cost of lost power; serves as another power source in energy demand generation. Current value is \$0.14/kWh (cost of diesel back-up generator). Having unmet energy requirements means the system must partially depend on high cost distributed generation to satisfy demands, or the system has unmet demands (black/brownouts)
- Unmet Reserves: Having unmet reserve capacity requirements means the system is not as reliable as it should be – the system is vulnerable to system outages. This cost is hard to quantify: current value is set at \$2000.00/kW.

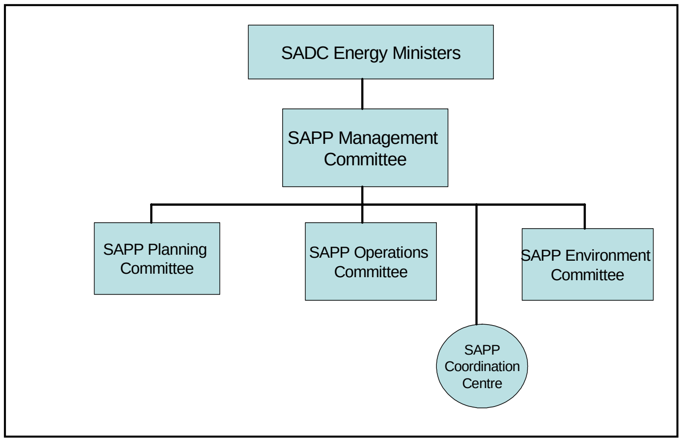
Country Autonomy (f)?

Need to protect against over-dependence on foreign sources of electricity

- Two types of restrictions:
  a) "x%" of electricity must be generated domestically – a domestic energy (kWh) requirement.
  b) "y%" of electric peak demands must be <u>capable</u> of being produced domestically: a domestic capacity (MW) requirement (still allows trade in kWh).
- In runs that follow, autonomy = 100% for limited trade scenarios (some trade takes place).

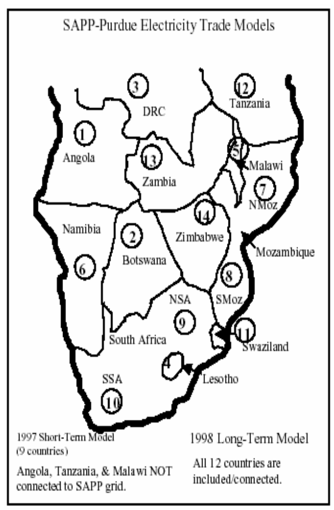
Existing SAPP Infrastructure

SAPP Pool Structure

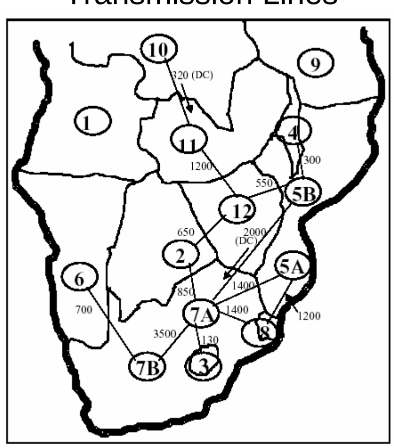


SAPP

- 12 Member States of SADC
- Legal establishment of SAPP power pool 1995
- Harare Coordination Centre 1999
- Purdue SAPP modeling 1996-2000



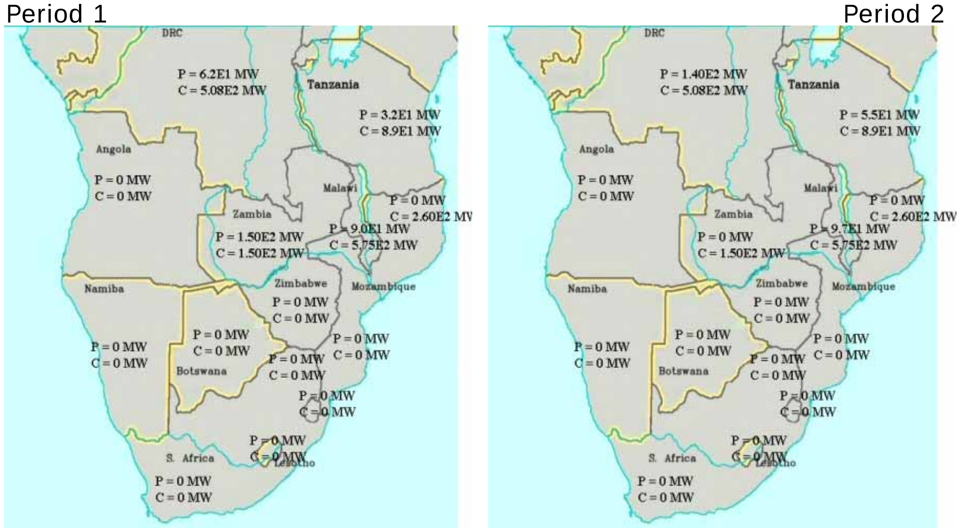
SAPP 2000 International Transmission Lines



SAPP Demonstration Results

New Hydro Projects

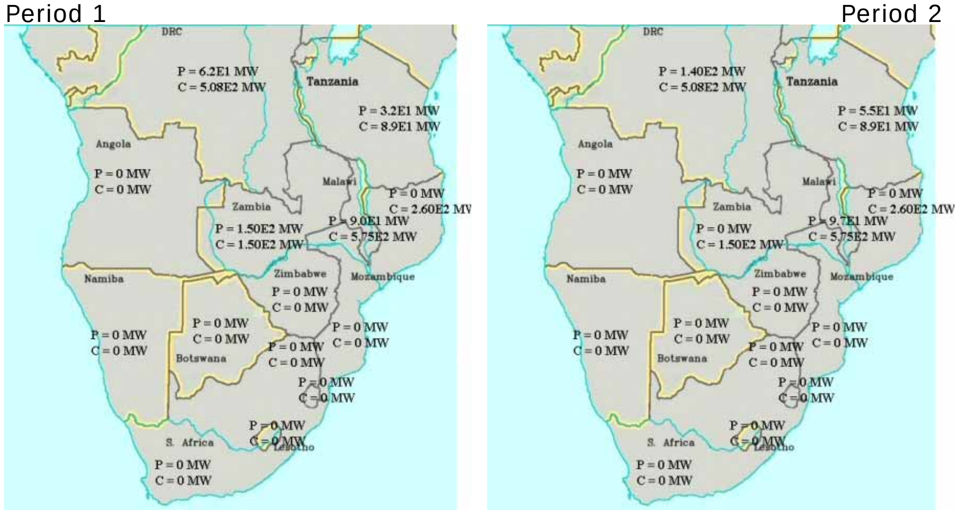
Period 1 Period 2



Note: Results for demonstration only

New Hydro Projects

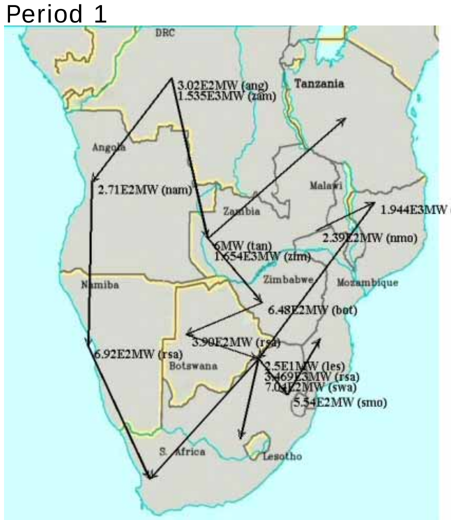
Period 1 Period 2



Note: Results for demonstration only

Firm Export Reserve

Period 1

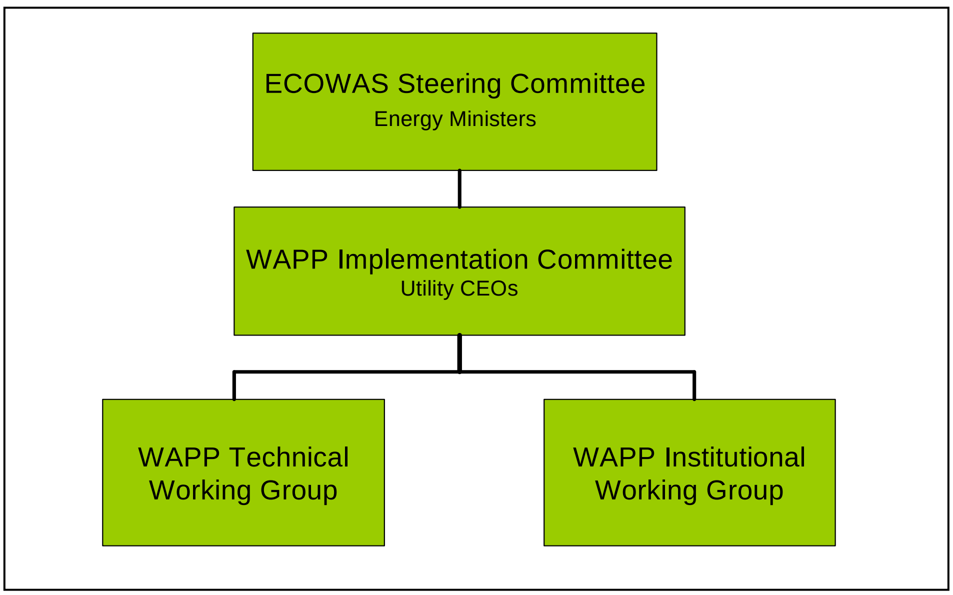


Period 2

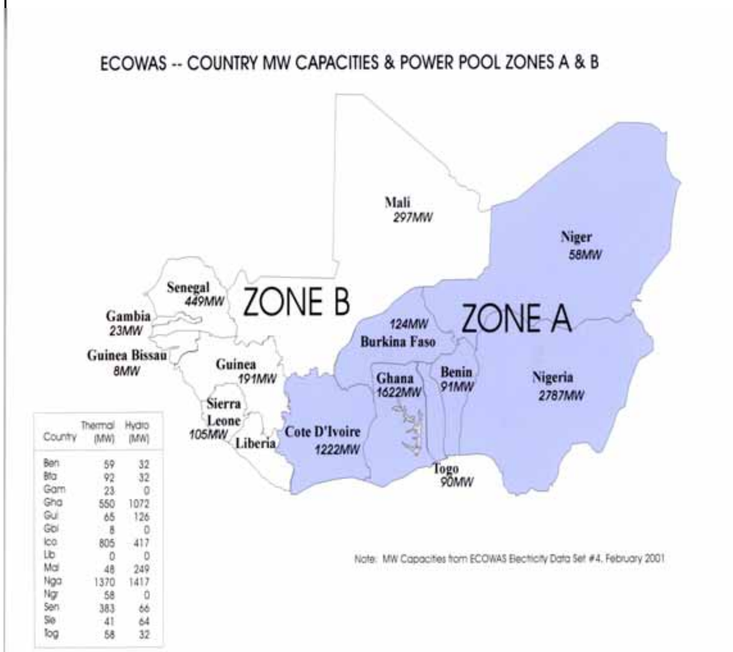
Note: Results for demonstration only

Existing WAPP Infrastructure

WAPP Pool Structure

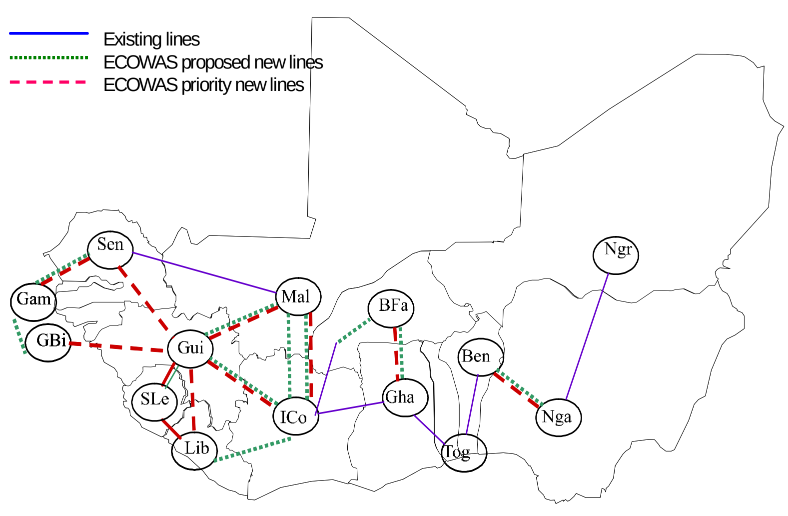


WAPP Zones A & B



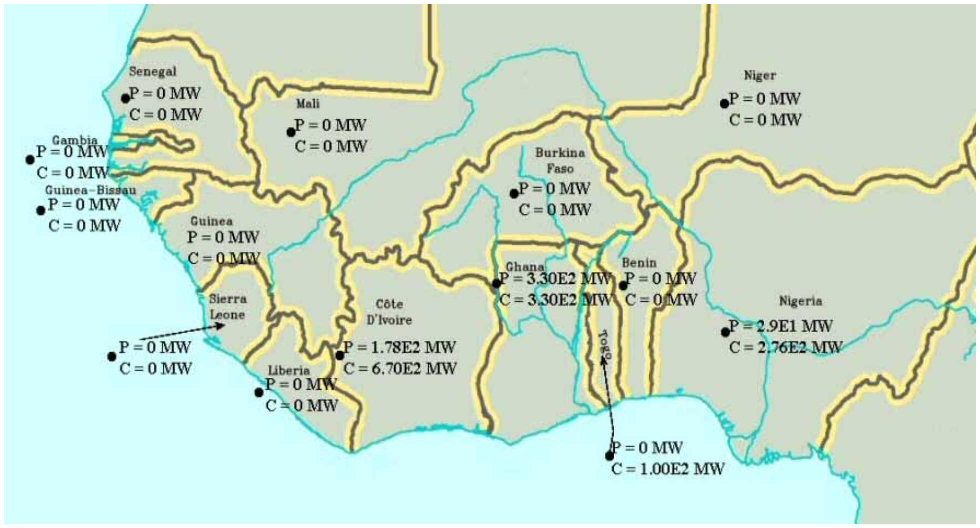
Country	Thermal (MW)	Hydro (MW)
Ben	59	32
Bfa	92	32
Gam	23	0
Gha	550	1072
Gui	65	126
Gbi	8	0
Ico	805	417
Lib	0	0
Mal	48	249
Nga	1370	1417
Ngr	58	0
Sen	383	66
Sle	41	64
Tog	58	32

WAPP Regional Interconnections



WAPP Demonstration Results

WAPP Combined Cycle Projects
Period 2



(Note: Results for demonstration only)

WAPP New Hydro Projects
Period 2

(Note: Results for demonstration only)

WAPP MW Reserve Exports
Period 2

SAPP and WAPP Demonstration Results

Impact Of Trade Restrictions
2000-2016
AF = Power autonomy factor
ENAF = Energy autonomy factor

	AF	ENAF	Total Cost ($ billions)
Base SAPP #1	0	0	11.6
SAPP #2	70%	0	27.6
SAPP #3	70%	70%	35.6

Note: Results for demonstration only

WAPP Free Trade Expansions 2003-2019
Demonstration Results

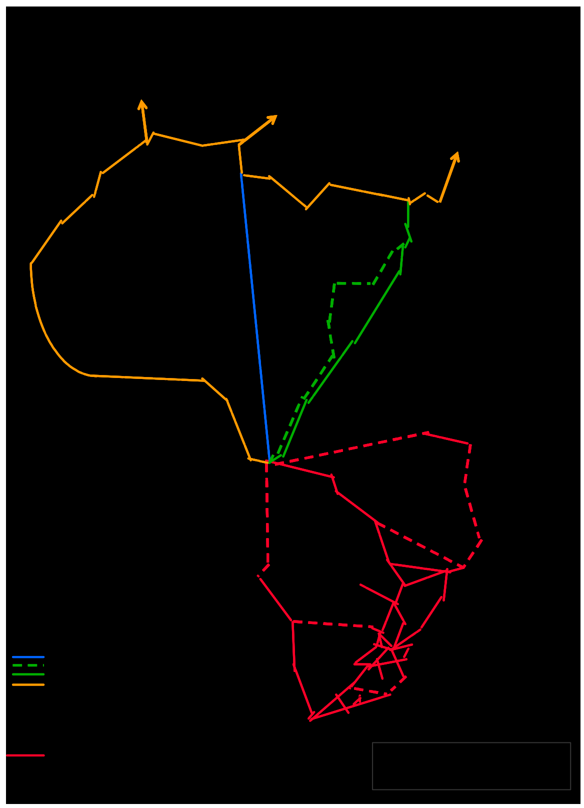
Free trade (FT) scenario for 2003 to 2019
(16 years: 4 periods with 4 years per period).
Capacity expansions are demonstrated.

- Existing transmission lines, 2,496 MW
- New transmission lines, 7,989 MW
- Existing thermal stations, 1,767 MW
- New combined cycle stations, 12,103 MW
- New gas turbines, 3,525 MW
- Existing hydropower stations, 560 MW
- New hydropower stations, 4,773 MW

Major Marketing Issues for Africa
in the 21st Century

- What electricity policy issues should take highest priority for Africa?
- Is transmission interconnection across the continent being substantially considered?
- How strategic is an "all Africa" energy regulatory body or reliability council?
- Is power pool growth in Africa developing at a fast enough pace – SAPP, WAPP, East Africa, Central Africa, North Africa?

Other Interconnections in Africa



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Rec'd 25-1-04

4. THE ENVIRONMENTAL IMPACT OF LARGE SCALE HYDROELECTRIC DEVELOPMENT: LESSONS FROM THREE GORGES

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Abstract: As a global recognition and concern over the potential effects of climate change due to the increasing levels of greenhouse gases in the atmosphere, hydroelectric becomes one of the most favorable renewable energies with no greenhouse gases emission. Africa is the continent that riches in the hydropower. However, most of them are not fully developed. There are general consents in the global community to develop the hydroelectric in this region to benefit both local community and neighboring countries. This panel would like to discuss the issues that have been encountered at the "Three Gorges" development in China. They will be the valuable references for the similar development in Africa.

4.1 Introduction

There is a global recognition and concern over the potential effects of climate change due to the increasing levels of greenhouse gases in the atmosphere. Globally, electricity production accounts for approximately 11% of human-caused emissions of greenhouse gases. More than one hundred countries have entered the agreement on the International Framework Convention for Climate Change (The 1992 Earth Summit Treaty in Rio de Janeiro and later reinforced in 1997 Kyoto Protocol). The objective of the convention was to ensure cooperative international efforts to deal with the climate change challenge.

Hydroelectric is considered as one of the renewable energies with no greenhouse gases emission. Africa is the continent that riches in the hydropower. However, most of them are not fully developed. There are general consents in the global community to develop the hydroelectric in this region to benefit both local community and neighboring countries. This panel would like to discuss the issues that have been encountered at the "Three Gorges" experiences in China. They are the valuable references for the similar development in Africa.

4.2 The "Three Gorges Project"

China has undertaken the largest project since the construction of the Great Wall -- the Three Gorges Dam project. The Three Gorges Dam will be the largest hydropower station and dam in the world, with a 1.2 mile stretch of concrete and a 370 mile-long reservoir and 525 feet deep. This project will cost more than any other single construction project in history. The project consists of the dam across the Yangtze River, the hydroelectric power station houses and the navigation structures. The crest elevation of the dam reaches 607 feet above sea level at Wusong. The spillway section is located in the middle of the riverbed, with the intake-dam and non-overflow dam sections on both sides of the spillway section. The power station houses will be placed at the toe of the dam on each side. Twenty-six (26) sets of hydraulic turbo generators, with 700 MW each, will be installed in the left and right powerhouses. This will have the potential to produce an annual electricity output of more than 80 TWh. The navigation structures are located on the left bank. The permanent navigation structures will consist of a double-way and five step flight ship locks and a single one-stage vertical hoisting ship lift, with the annual one-way passing capacity of 50Mt. The Three Gorges Project is the backbone project for the developing and harnessing of the Yangtze River, and it will result in a great deal of comprehensive benefits, such as effectively controlling the floods, generating powerful electricity, and improving the navigation condition. It will also, however, exert far-reaching and profound impacts on the environment, which has brought ecological and environmental concerns both at home and abroad.

4.3 Major Benefits from the Project

Flood Control

The Three Gorges Project will control 95% of the Jingjiang section's flood inflow and 66% of the flood inflow upstream Wuhan City. It can improve the flood control capability in Jingjiang section from controlling a ten-year's flood at present to a hundred-year's flood in the future. It will also greatly mitigate the flood threat of the Yangtze River to the Dongting Lake area and decrease flood losses. It greatly promotes the reliability and flexibility of flood control operation in the middle and lower reaches of the Yangtze River.

Power Generation

The hydroelectric station of the Three Gorges Project will have a total installed capacity of 18,200MW with the potential annual electricity output of more than 80TWh.

Navigation

The Three Gorges reservoir will improve navigation conditions in the section from Yichang up to Chongqing. Fleets of 10,000-ton towboats will be able to pass through right up to Chongqing port. The annual one-way downward passage capacity will be increased from the present 10 Mt up to 50 Mt and the transportation cost will be decreased. During dry seasons, the flow downstream Yichang will be increased and the navigable channel depth will be deepened. As a result, the navigation condition will be significantly improved.

Environmental

The flood control function of the project will reduce the serious damage to the environment and ecosystems that would be otherwise caused by disastrous floods in the densely populated and economically developed plain and lake areas in the middle reaches of the Yangtze River, and relieve the local residents from the mental burden and risk posed by floods. Also the reservoir regulation would slow down the sediment deposition in the Dongting Lake that will prolong the life span of the lake.

Hydroelectric power is a type of clean energy. Large amounts of sulfur dioxide, carbon dioxide, carbon monoxide, nitrogen oxides, would be produced if the Three Gorges Project were replaced by coal-burning power stations to produce the same amount of electricity per year. The Three Gorges Project is to reduce emissions of sulfur dioxide and carbon dioxide that is equal to about 40 million tons of coal.

4.4 Debate Over the Project

Cost of the Construction and Potential Payback

The project is thought to have cost more than any other single construction project in the history. The unofficial estimates as high as US$75 billion (Official estimation for the project is around US$10-15 billion dollars).

Those from Probe International, a Canada-based organization opposed to the dam, believe that by the completion of the project, competition from cheaper, superior alternatives will have drawn away the ratepayers. It will be impossible to recoup the investment in the project.

Meanwhile, critics fear that other projects in need of investment will suffer as China throws all of its resources into one big boondoggle.

Resettlement

In the 1980s, China passed regulations to protect the rights of those displaced by the dam projects and assure them of adequate compensation. But human rights activists asserted that rural dwellers are being discriminated, that they are not being consulted about their eviction, that they are often crowded onto poor land with unsatisfactory living conditions and few job opportunities. Many critics believe resettlement would fail and create reservoir refugees. The forced migration would raise social unrest. Many of the residents to be resettled are peasants. They would be forced to move from fertile farmland to much less desirable areas.

Environmental

The dam would alter the current ecosystem and threaten the habitats of various endangered species. The project would need extensive logging in the area and erode much of the coastline. Others said such a large dam would increase seismic activity in the area and that a consequent earthquake could burst the dam, especially if construction is faulty.

Local Culture and Natural Beauty

The 600-kilometer (370 mile) long reservoir would inundate more than one thousand (1000) archeological sites, destroy the beauty of the Three Gorges and thereby substantially reduce the tourism revenue.

4.5 Possible Alternate Approaches

Factors of Consideration

The normal pool level (NPL) scenarios of the Three Gorges Project, ranging from 128 to 260m, have been repeatedly compared and studied, including those for development in phases and in cascades. A higher dam could have significant benefits in flood control and in exploitation and utilization of water resources, while resulting in huge inundation losses and greater ecological and environmental impacts. A single cascade, with its construction to be completed at a time, the water storage to be increased in several phases, and the resettlement to be conducted successively has been finally selected for the project. However, it is believed that the primary motive for the final selection is political. The dam would be the world's largest hydroelectric dam, which would confer prestige on China and confirm its technological prowess and the superiority of socialism. To have better evaluation, the political motive should be minimized and the regional inundation losses and ecological and environmental impacts should have higher priority during the planning and development of hydroelectric resources in the continent of Africa.

Resettlement Planning

As stated in some critics, the forced migration will raise social unrest and create reservoir refugees. This is because they are not being consulted about their relocation and they are often crowded onto poor land with unsatisfactory living conditions and few job opportunities. Many of the residents to be resettled are farmers. They would be forced to move from fertile farmland to much less desirable areas. The following items are critical for a successful resettlement:

- Communicate with the Settlers. It is difficult for those people who have lived in the same location for several generations to relocate to a new area and start from the beginning. In addition to the physical preparation, mental readiness is equally important.
- Create job Opportunities and Provide Training. Provide housing for the settlers is the easiest part for the whole resettlement process. After relocation, settlers may not be able to continue their original jobs due to unavailability or unfavorable working conditions. Create new job opportunities and provide training for the new jobs can reduce the social unrest and help settlers with smoother transition.

4.6 Conclusions

Hydroelectric is considered as one of the renewable energies with no greenhouse gases emission. As a global recognition and concern over the potential effects of climate change due to the increasing levels of greenhouse gases in the atmosphere, hydroelectric becomes one of the most favorable forms of renewable energies. Africa is the continent that riches in the hydropower. However, most of them are not fully developed. There are general consents in the global community to develop the hydroelectric power in this region to benefit both local community and neighboring countries. However, one has to minimize the regional inundation losses and ecological and environmental impacts and establish a well-planned resettlement approach during the planning and development of hydroelectric resources in the continent of Africa.

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Biography

Wei-Jen Lee received his B.S. and M.S. degrees in Electrical Engineering from National Taiwan University, Taipei, Taiwan, in 1978 and 1980, respectively, and a Ph.D. degree in Electrical Engineering from the University of Texas at Arlington in 1985. Since then, he joined the Electrical Engineering Department at University of Texas at Arlington. He is currently a Professor of the Electrical Engineering Department and the Director of the Energy Systems Research Center. He has been involved in research on power flow, transient and dynamic stability, voltage stability, short circuit, relay coordination, power quality analysis, and deregulation for utility companies. He is also involved in research on the design of integrated microcomputer-based monitoring, measurement, control, and protection equipment for electric power systems. He is a senior member of IEEE and a Registered Professional Engineer in the State of Texas.

Rec’d 30 Jan 04

(5) AFRICAN POWER POOL INTERCONNECTIONS DEVELOPMENT: A FOUNDATION FOR BRIDGING THE DIGITAL DIVIDE (PAPER 03GM0399)

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Abstract

This presentation attempts to recommend and demonstrate an opportunity for African policy makers to utilize the information density created by the planning of some of these energy development initiatives to integrate with international R&D in the growing field of knowledge management.

The South African power pool (SAPP), West African power pool (WAPP) and the initiatives in North Africa with interconnections to the Middle East represent vast knowledge domains. These domains range from economic to cultural to historical. Modeling the intent therefore of these initiatives (i.e. a given power plant, series of plants or development projects in a given system) generates technical and societal ‘impact’ data across academia, industry and other sectors of society. Several studies are cited to illustrate the growing importance of ‘knowledge management’ versus ‘knowledge transfer’ and the resulting possibilities.

In turn the principal studies on African interconnections are cited as foundation candidates toward building these knowledge bases. References from contemporary events such as The California Energy Crisis and projects such as the Three Gorges Project in China and the Brazilian Hydro experience are also cited for their own internal knowledge experience.

KEYWORDS: Electric power generation in Africa, systems theory, knowledge base, knowledge management, implicit knowledge, explicit knowledge

Introduction

This study attempts to create a platform by which the fast pace of information importance and knowledge management can serve in dynamic roles to developing societies (emerging economies) while recognizing the challenges of Basic infrastructure inadequacies. The study draws on knowledge management models namely the SECI model and the Dynamic Parameter Model, which are theoretical paradigms, used to generate, analyze and utilize data within given ‘domains’. Here the suggest domains are the emerging initiatives in the African Energy sector. By definition these models or paradigms distinguish ‘Knowledge Management’ from IT, as it is generally understood. This will be addressed in proceeding chapters. Utilizing an introduction to IT from a university curriculum which helps bring into focus some of the discussion o power pool interconnection development. The African Sectors of focus are the South African Power Pool (SAPP), West African Power Pool (WAPP) and the initiatives in North Africa with interconnections to the Middle East and Europe (NAPP).

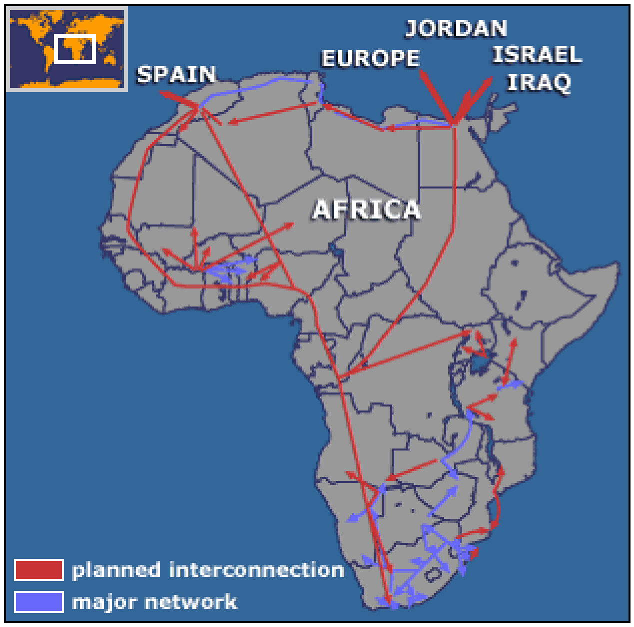

Figure 1

Principal Studies

The Purdue long-term economic model (ref 9) has analyzed a variety of scenarios linking generating sources to load centers under different seasonal and system operating conditions for the South Africa, Central Africa and West African Regions. These studies shall be referenced. These studies are therefore sited as foundation candidates, which serve to create platforms from which knowledge models such as the SECI model or Dynamic Parameter model can generate interdisciplinary synthesis over a wide range of applications. The information density contained within these sector initiatives provides sufficient 'Synthesizing Capability' for digital infrastructure. The information density referred to is not limited to the 'classical attributes' being looked at in the particular studies namely, Megawatt transfers, transmission stability, generating capacities, operations etc. These 'classical attributes' in the domains defined by this study can be core (Baseline) and strategic information which Knowledge models abstract, instantiate or synthesize for various applications. e.g. education in a virtual or non-virtual environment.

The EPRI Electricity Technology Road Map Initiative is another principal study on the cutting edge and is core to this study as it represents a synthesis of global Industry Experience and R&D. *With over 150 participating electricity stakeholder organizations, the Roadmap seeks to develop a comprehensive vision of opportunities for electricity-related innovation to benefit society and business. The Roadmap also translates that vision into asset of technology development destinations and ultimately the needed R&D pathways*.Ref.8. The Creation of the Roadmap began with the exploration of opportunities in five distinct topical areas:

- Sustainable global development
- Electricity and economic growth
- Power Delivery Infrastructure
- Power Production
- Environmental Knowledge Base (Ref.8)

The Road Map initiative and the raw resources data associated with African development possibilities can be one such synthesis which can produce a 'New Reality' Nonaka et al. [1a].

The Digital Divide

In suggesting that these Complex energy development initiatives can serve as a foundation to establish strategic institutional network infrastructures it is imperative that some contemporary base concepts from IT and its subsequent transition to Knowledge is introduced to define scope.

Complex Adaptive Systems, Knowledge, and Systems Management: Complexity theory is an emerging field of study that is evolving from several major knowledge areas: mathematics, physics, biology, economics, organizational science, computational intelligence and systems engineering. It is a needed set of endeavors brought about by two realities. The first is that modern science often does not reflect all of reality, but only the part of reality that is ordered, linear, ergodic, isolatable, predictable, observable, and controllable.

The second reality is that modern trends toward disciplinary specialization run counter to the major need for knowledge integration and transdisciplinarity for resolution of contemporary issues. Fundamentally, a system is complex when we cannot understand it through simple cause-and-effect relationships or other standard methods of systems analysis. In a complex system, we cannot reduce the interplay of individual elements to the study of those individual elements considered in isolation. Often, several different models of the complete system, each at a different level of abstraction, are needed. There are several *sciences of complexity*, and they generally deal with approaches to understanding the dynamic behavior of units that range from individual organisms to the largest economic, technical, social, and political organizations. Many of these studies are agent or element Based and involve complex adaptive systems and hierarchical systems. The structure and behavior of these complex systems is not dictated uniquely by the edicts of a leader, but emerges and evolves in a natural manner through the interactions of the agents.

One measure of system complexity may be the complexity of the simulation model necessary to effectively predict system behavior. The more the simulation model must look like the actual system to yield the same behavior, the more complex the system. As a general rule, we cannot create models that will accurately predict the outcomes of complex systems. We can, however, create a model that will accurately simulate the *processes* the system will use to create a given output. This awareness has profound impacts for economic, organizational, and many other efforts that are concerned with systems of systems that are also of large scale and scope. Most studies of complex systems often run completely counter to the trend toward increasing fragmentation, compartmentalization, and specialization in most academic disciplines. The current trend in complexity studies is to reintegrate the fragmented interests of disciplines into a common pathway. Without cohesive systems ecology to guide development and use of information and associated knowledge, and without the necessary knowledge integration, engineering and management of complex systems is unlikely. Ref. 3

Knowledge Models

The SECI Model

There exist various definitions of knowledge and knowledge management. In this paper; we rely on the learning model proposed by Nonaka and Takeuchi [ref1b]. This learning model categorizes knowledge into tacit and explicit forms. Based on these two forms of knowledge, the model differentiates four ways of transforming knowledge. They are socialization, externalization, internalization, and combination.

Knowledge needs context - Without context to specify time, place, and relationship with others, it is just information.

Ba is a context that is shared by participants to create meanings (=change the context).
Participants understand the contexts of others and oneself, and through interaction, change/create the contexts. Hence, it is constantly moving.

The key to understand context is interaction. Knowledge does not just reside in one's mind. Knowledge emerges through shared contexts that are created through interaction. (Ref.1a)

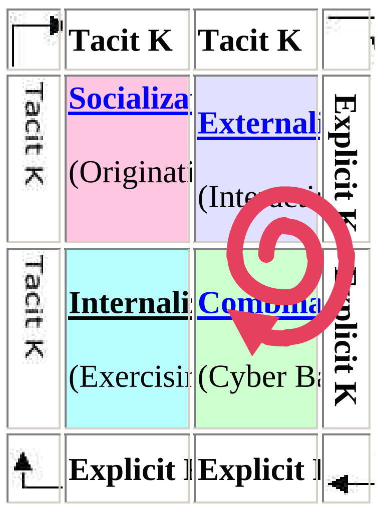

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Figure 2

There are two aspects in what is meant by the word "knowledge": "tacit knowledge" and "explicit knowledge". The former entails experiential, physical (or perceptual) analogue knowledge, which cannot be described in words. The latter is digital knowledge, the tacit knowledge converted into explicit words or systems. If this explicit knowledge is separated from the people who own it or the site in which it exists and turned into documents or charts, it is called "semantic information". Reference 2

Technologists have specialized knowledge of both technology and customers. Knowledge workers in the fields of research or planning create new ideas. If the entire corporation can share their knowledge, it would be extremely useful and beneficial to the work of the other people. It would further benefit the company if such knowledge is not only shared but also utilized to create new knowledge.

In order to make these things happen, there must be "Ba" for knowledge creation. "Ba" means internal communities of groups of technologists or knowledge workers who share the same interest or purpose. More specifically, they are cross-functional human networks or groups including virtual relationships on intranets, extranets or the Internet. These communities are called COP (communities of practice). (Ref.2)

The Dynamic Parameter Model

In the Dynamic Parameter study a “Dynamic Parameter” is an evolved entity abstracted from a selected object that manifests significant information density or convergence. Represented by Figure 3. (Ref.5)

Figure 4 shows its location in a given domain under analysis and where Ba takes place.

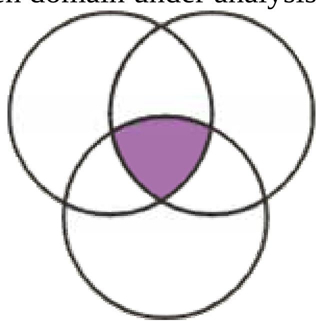

Figure 3

In this instance the object or entity can be a real or projected power plant within one of the power pools being looked at namely the WAPP, SAPP & NAPP. Figure 4 is illustrative of relationships that are created.

The input on the object can be from

a) ‘Lessons Learned from a similar plant’ outside that system
b) A focus on the impacts to the immediate environment as a case study.
c) An analysis of it’s role within the System, e.g., Base load, Peaking, Voltage stabilization
d) A number of Academic Disciplinary abstractions

The continuously evolving interaction on multiple levels coming from the source of the ‘explicit knowledge” (the power plant and its role in the domain) is Ba itself and what transforms an object or entity into a “Dynamic Parameter” or new reality.

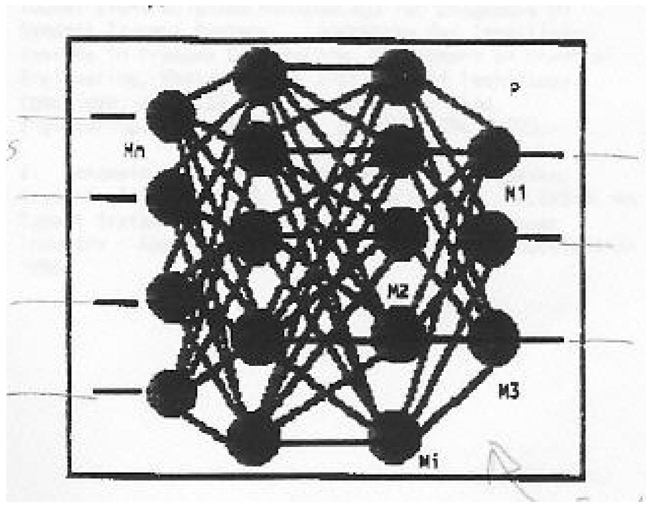

Figure 4

Synthesizing Capability

As globalization as a trend continues with improved telecommunications technologies so to does the opportunity present itself for creating these focused domains between Africa and the international community on Micro and Macro scales. Figs 5 and 6 for example illustrate two global realities in and out of Africa that are important to the discussions of any continental energy development i.e. the state of nuclear energy use around the globe and the state of disappearing rainforests around the globe (ref.4). Fig.5 can create the **"Ba"** to contemplate **nuclear waste issues**, **technology dependency** and **security issues**.

Nuclear Reactors Worldwide

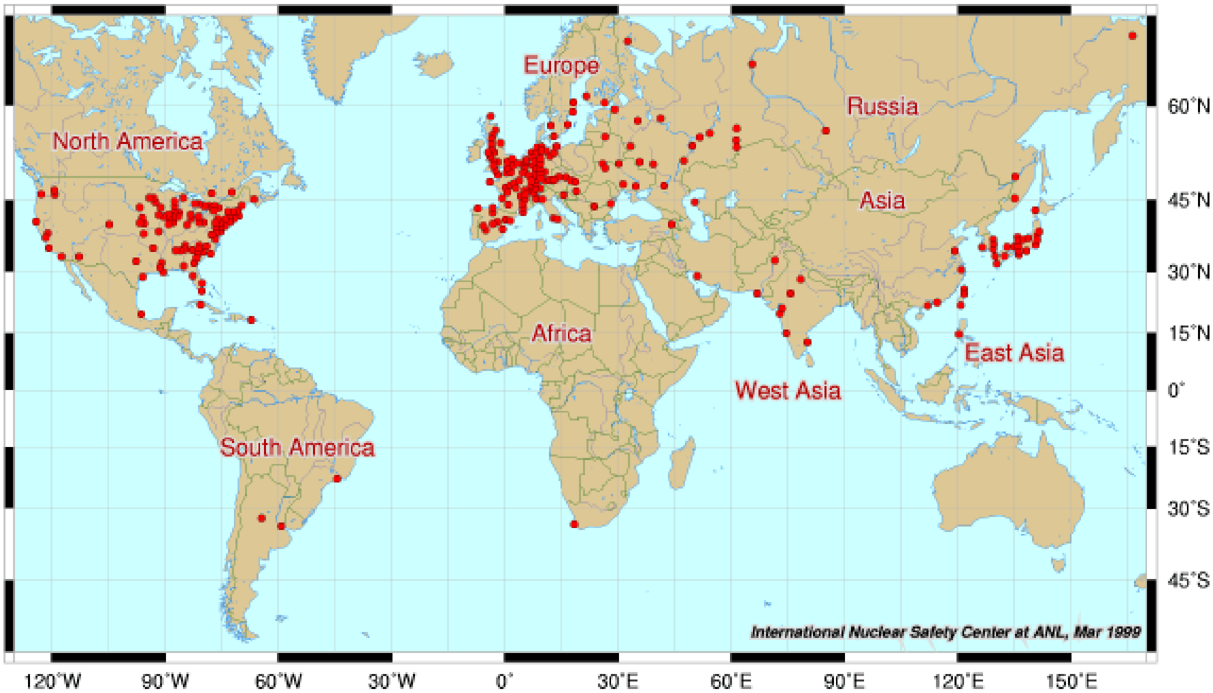

Figure 5

Figure 6 Can create the **"Ba"** of issues relating to ***disappearing rainforests***, ***animal protection***, ***plant medicines (genomics), inter state river management***, and the debate over the *minimization or maximization of* ***hydroelectric development*** within the context of options. Here interactive knowledge from the Hydroelectric Power Plants of ***Inga –Three Gorges-Itaipu*** can be used to create **Ba**. Itaipu for example due to low water levels created the need for emergency installation of LM6000 gas turbines to compensate for the power deficiency.

The World's Disappearing Forests

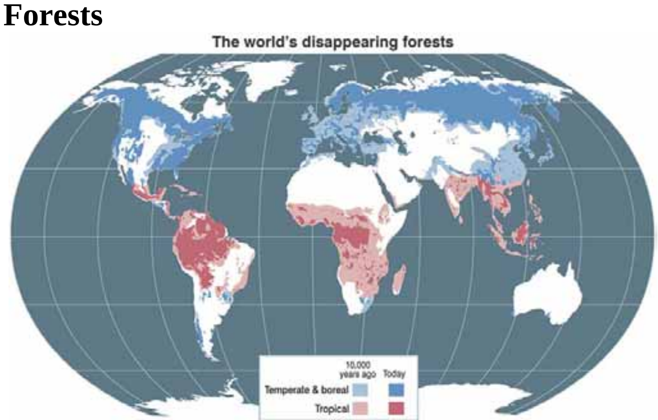

Figure 6

Meanwhile the Country of Angola with estimated reserves of 1.6 TCF of natural gas flares approximately 85%. A "**Ba"** of ***Natural gas exploitation*** and ***hydroelectric optimization*** can then be created across all the South African Power pool since this is the 'domain' in which a key element

INGA resides. Another example applicable to the Africa program is the dynamic or Ba potential between ***Three Gorges*** and the ***Zambezi river basin development*** and ***flood control***.

Conclusions

This creation of communities of practice among African utilities, universities and international institutions utilizing data from within their immediate reality is a desired result of this paper. A focus on California where the Global Power industry is being reinvented is also key in the establishing of those communities. Deregulation and the 2001 Energy brought into focus weaknesses inherent in the model and brought on by Price swings in natural gas, constraints in transmission capacities, drought conditions affecting Hydro Generation and newly tested financial models.Ref.10

Knowledge Engine

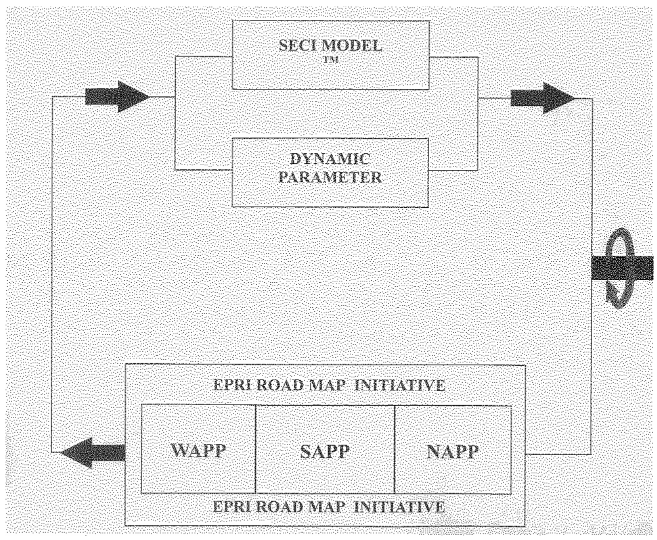

Figure 7

This focus would support NEPAD and the Africa Union as they seek institutional convergence towards developmental efficiency. This approach to knowledge management while on the cutting edge and in many instances remote from the reality of many of the countries in question strategically exercised through dedicated INTRANETS can significantly narrow the widening digital divide.

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Biography

Bai K Blyden is an Engineering Consultant, BBRM Investments, LLC, USA. He received the degree of MS.EE from Moscow Energetics Institute in 1979. He specialized in Power Systems, Generation and Industrial Distribution Systems with a Minor in Computers. He works as an Engineering Consultant in the US Power Industry where he resides. Mr Blyden has worked on over thirty power plants and their associated interconnections throughout his career in various capacities of distribution planning, electrical control systems design, management and construction. He has held contract staff positions with various Utilities such as TVA, PG&E, The New York Power Authority and Entergy. He has also been b employed by the major AE firms including Bechtel, ABB ASEA Brown Boveri, Stone & Webster and Gibbs & Hill. While at ABB Mr.Blyden successfully led engineering teams that prepared Kansas Gas & Electric 950 MW Wolf Creek Nuclear Plant and Georgia Power's 2x 1215 MW Plant Vogtle for Nuclear Regulatory Commission Electrical Distribution Safety Functional Inspection (EDSFI) audits. He most recently served as assistant Project Manager on the CALPINE California Peaker Program, which involved the planning, and construction management of eleven GE LM6000 gas turbine Peaker units around Silicon Valley during the 2001 CA Energy Crisis. He is a member of the IEEE International Practices Subcommittee and serves as consultant to GENI (Global Energy Network International).

Bai Blyden is the author of several papers on African Energy Development published in various IEEE publications (1983-2000). He introduced the theoretical concept of a 'Dynamic Parameter', which he presented at MIT and at the IEEE Systems, Man and Cybernetics society conference, 1992, which relates to Expert Systems and Artificial Intelligence applications for Power Plants. He has lectured extensively on African Energy Development issues to Institutions and more recently to Investment groups. Mr.Blyden was one of the early advocates of an all Africa Grid and presented a conceptual framework and technical analysis for a centralized African Power pool with links to North Africa at the first Region 8 IEEE conference held in Nairobi, Kenya, 1983.

(6) US AFRICAN POWER RESEARCH AND EDUCATION ACTIVITIES: CHALLENGES, EXPERIENCES AND OPPORTUNITIES

[1]James A. Momoh, PhD, FIEEE, *Program Director*, Electrical & Communication Systems (ECS), National Science Foundation, Arlington, VA 22230

Summary

The College of Engineering, Architecture and Computer Sciences (CEACS) and the Center for Energy System and Controls (CES&C) at Howard University have received prior research funding for supporting international workshops on power system operation and planning in Africa. Over the past ten years, the National Science Foundation (NSF) has supported the hosting of the International Conference on Power System Operation and Planning (ICPSOP) in various African countries namely, Nigeria, Ghana and Ivory Coast. Future sponsored workshops will be hosted in Durban, South Africa in 2005 and in Cape Verde in 2007.

NSF Grant number **ECS-0115575** supported the most recent workshop that was held in Abuja, December 16 – 18, 2002 through a grant of value $44,500.00 to support participants and conference activities. The conference was organized by Howard University with Nigeria's National Electric Power Authority (NEPA). Under the theme "*Experiences and Challenges of the Restructured Power Industry*", the grant for the workshop enabled over 15 US representatives and 10 African students to participate and contribute to the power system challenges and experiences brought forward at the workshop. The participants were selected based on their backgrounds in power system restructuring and interest in implementation of United States-Africa power initiatives. The combined support from United States utilities, vendors and government agencies such as US Department of Energy (DOE), American Education Institute (AEI), Howard University, and several African power companies such as NEPA, South African Power Pool (SAPP), and the Volta River Authority (VRA) has helped to organize and launch biennial workshops on common topics of interest to the US power industry and African utilities.

Overall, each of the past five workshops has attracted participants and representations from over 10 universities in the US, professors and graduate students, and also their counterparts from 19 African countries. The participants acknowledged and benefited from technology trends in power systems as well as emerging research and technology to address currents needs. The workshop has been established as an opportunity for US power systems professors and students under the sponsorship of NSF, and US power industries to provide exchange information and experiences between Sub-Sahara Africa and the United States. The workshop has also helped to facilitate involvement of minorities and women in technology in an international forum. Over the years, participants from the US and Africa have judged the conferences to be valuable and of excellent quality.

The peer-reviewed papers that were presented addressed current issues and methodologies and served as a vehicle for understanding power system activities among countries. Panel sessions addressing power policies in the US and Africa, as well as tutorials in deregulation and restructuring, information technology trends and environment were held. A communiqué summarizing views of conference participants in the future of the electricity industry and the United States-Africa participation was composed. Proceedings of the workshop were published and made available to educators, researchers and potential sponsors.

Former workshops outcome have been tracked and some of the findings include:

- US utility companies who attended have won opportunities to do business with Africa power industry as consultants, vendors, etc.
- Recruitment of outstanding doctoral students into United States universities with power programs, for example, Howard University, Tennessee Tech, Texas A&M, and Washington State University (WSU).
- Joint projects between United States power industry and African universities and industries. For example, joint projects between Howard University and Kwame Nkrumah University of Science & Technology (KNUST), Monsura University, etc.
- Exchange program between the United States and Africa.
- US industry and power consultants have become interested in business in Africa. This includes K&M Engineering and Consulting Corporation and the US Education Institute, Inc. (AEI).

Impact of Research and Education Activities

The following results have been realized from previous workshops:

- As a result of the recruitment efforts from the workshops over the years, several graduate students from Ghana, Nigeria and Kenya are enrolled at Virginia Polytechnic Institute (VPI), Howard University and Tennessee Tech.
- Research fellows from among the conference participants are employed with various US power system industries such as Siemens Empros and Howard University.
- Howard University in Washington DC and University of Washington in Seattle are engaged in proposal writing in support of pricing and reliability in a deregulated utility industry in Sub-Saharan Africa and the US.
- Several other collaborative efforts between US and African professors for joint conference and research activities under the sponsorship of the National Science Foundation (NSF). The African countries have established a new partnership, which led to our ability to secure increased funding from local utility sponsors.

From these results and the interest shown by potential participants surveyed, it is evident that there are many opportunities for further collaboration between African power engineers, and US especially in the new deregulated utility environment.

Finally, Howard University hosted the NSF-Sponsored US-African Research and Education Collaboration in Power/Energy, Information Technology and Environment at the Ralph J. Bunche International Affairs Center, Howard University on November 5-13, 2003. Under the sponsorship of NSF, a local committee at Rensselaer Polytechnic Institute (RPI) coordinated this premier workshop. Participants from Western, Eastern, Central and Southern parts of Africa, and the US deliberated and exchanged ideas on power policies, IT, and other issues from their respective countries. The US-Africa Research and Education workshop is an outgrowth of the biennial ICPSOP, which the NSF, a host of utility companies, and universities in the US and Africa have funded in previous years. The workshop paved the way for more rigorous research activities and collaboration in Energy, Information Technology and Environment.

Communiqué: 5th International Conference on Power Systems Operation and Planning (ICPSOP 2002)

The conference held in Abuja, Nigeria, December 16 – 19, 2002, provided a technical forum for the exchange of ideas and sharing information on the "Experiences and Challenges of the Restructured Power Industry" by participants from U.S.A, Europe and Africa including Nigeria, Ghana, Guinea, Niger, Senegal, South Africa, Cameroon, Sierra Leone, Egypt, Zimbabwe, etc.

The Conference Vision Statement

The conference will transfer technologies that allow economic and reliable electricity to be provided to every household in the sub-Sahara region of Africa by the year 2020

Analysis of Issues

The following issues were discussed:

1. Evolution of computational tools to meet the needs of the Restructured Utility Environment to account for uncertainty and randomness.
2. The need for benchmarking test cases to be established based on the new computational tools.
3. The need for engineering curriculum in universities to be updated to include power system economics, finance contracts management and new application tools.
4. Application of Information Technology in the deregulated power delivery system.
5. Technology to extend the life of the equipment.
6. Frequency stability and voltage regulation.
7. Social – Economic Impacts of Deregulation.
8. The need for standards.
9. A well-designed and structured electricity market, and rules needed to enhance competitive environment.

Recommendations

As the government, industry, and the public consider the options for power industry regulatory reform, the uncertainty inevitably leads to confusion and anxiety. Based on the experiences of such reforms in other parts of the world, the conference made the following general recommendations:

1. It is necessary to first articulate the objectives of the restructuring exercise.
2. Deregulation can involve privatization, unbundling, and a competitive market environment. Specifically what is the most beneficial direction for West Africa? Should privatization mean outright sale of assets or granting of management concession? Participants favor concessions.

3. Conduct detailed research to develop a well-thought out plan that includes appropriate measures to avoid pitfalls of the industry reform. An example is that a privatized generation market can lead to price hikes/volatility that impacts the consumers.
4. Establish a systematic program to allow Engineers/Researchers/Governments in United States and West Africa to work closely together to share ideas and experiences and develop a knowledge base and a pool of talents well versed in the technical and socio-economical aspect related to power restructuring around the world.
5. From discussions, it is clear that issues involved in ESI deregulation are highly complex and need to be studied in detail, e.g., the relevance of full availability of infrastructure (transmission network, gas supply network, etc., telecommunication, etc,) to achieving competitive markets. The conferees strongly recommend that technical people should be fully involved in policy decisions.
6. The technical workforce must be retrained to embrace professionalism in consonance with the demands of envisioned restructuring of the power industry.
7. Stronger efforts must be put in place to attract young scholars from high schools through post-graduate school to major power and practice the profession to address the current decline in the number of future power engineers. (It was observed that in United States and Europe where deregulation has taken place, attraction for engineering has declined as shown by falling enrollment for power engineering courses. (Participants believe that over-regulation by regulators of the industry-- who themselves are not familiar with the power industry-- make rules that force companies to operate on "bare bones" budgets, thus leaving no room to address system reliability and improved technology costs. Hence, "jobbers" rather than professionals are attracted to the industry.)
8. Education of future entrants into the power industry must be broad based and include, legal, finance, international languages of commerce and emerging technologies of 21st century.
9. Some basic equipment is necessary for monitoring and controlling the power network. This result in improved efficiency and continuity of service, local participation in the manufacture of some of this equipment will facilitate the realization of this objective.
10. Electricity is a human right, essential for development. Governments should take responsibility to make sure everybody has access to electricity through graduated pricing.
11. An appropriate regulatory framework should be established, with proper leadership knowledgeable about the industry to ensure proper functioning of the restructured power industry. This will include enforceability of contracts, land issues, etc.
12. The regulatory framework for the power industry must include special provision to encourage utilization of renewable energy technologies operating as dispersed, distributed, and embedded generation. The potential for the utilization of the technology in Africa is immense and should be developed as part of overall energy policy.
13. Governments should identify a reasonable timeframe for the restructuring exercise by first conducting a dry run to establish a reasonable minimum time for each activity involved.
14. Participants recommend strongly that there should be a stakeholders' meeting prior to reorganization of ESI. The stakeholders will include but not be limited to manufacturers, engineers who are working in the industry, representatives of labor, policy makers, and owners of ESI to discuss the ongoing restructuring process.

James A. Momoh (M'76-SM'89, F'99) received the B.S.E.E. degree from Howard University in 1975, the M.S.E.E. degree from Carnegie Mellon University in 1976, the M.S. in Systems Engineering from the University of Pennsylvania in 1980 and the PhD in Electrical Engineering from Howard University in 1983. He is a former Chairman of Howard University Department of Electrical and Computer Engineering.

In 1987, he received a National Science Foundation Presidential Young Investigator Award for his scholarly achievement, research and education efforts. He is currently Program Director for Power/Energy of Electrical and Communication Systems Division, National Science Foundation (NSF), where he is on sabbatical leave from his position at Howard University as Professor of Electrical Engineering and Director of the Center for Energy Systems and Control (CES&C). His current research activities are concentrated in stability analysis, power system security and development of computational tools for power system reliability assessment, optimal power flow for restructuring of the power industry, and intelligent system application of artificial neural networks, fuzzy logic and genetic algorithms to power system automation for utility firms, aerospace and naval systems.

Currently at NSF, he initiated the development of interdisciplinary program in Power Systems, Economics, Environmental and System theory for secured, efficient power networks which led to awards of grants to address the grand challenges of power networks design, operation and control. He is the coordinator of the US-Africa Research and Education Collaboration in Power/Energy, Information Technology (IT) and Environment, which have led to joint research efforts between US professors and their counterparts in Africa. He is a Fellow of the both IEEE and Nigerian Society of Engineers (FNSE) and a recipient of many numerous awards.

(7) STATUS OF INTERNATIONAL INTERCONNECTIONS IN NORTH AFRICA

Ahmed Zobaa, Cairo University, Egypt

Interconnections between neighboring utilities are becoming increasingly vital for the implementation of an open energy trading market and to increase the reliability of power systems. The power utilities of the Arab countries in North Africa and the Middle East have made considerable investments in extending transmission system interconnections and power-transfer corridors at various voltage levels to facilitate the cross-border trading of electric power. Progressive development of interconnections, either between neighboring countries or within separate island power systems in one country, can be affected by the distances separating capital cities, power pools, population density and the Sahara Desert.

The interconnection between power systems benefits neighboring utilities. It takes advantage of the diversity factor or time difference of peak load periods on national systems, defers foreseeable investment in generating and operating costs, reduces the rate of system outages, enhances reserve margins and supply security, thus improving reliability. However, this is not always the case when the systems are geographically separated by large distances and are not designed with a meshed structure.

North African Interconnectors

Libya is a large country that shares borders with six neighboring countries, four Arab states (Egypt, Sudan, Algeria and Tunisia) and two African states (Chad and Niger). Currently Libya is only electrically interconnected with Egypt at the east network boundary where energy has been exchanged through the tie line since the circuit was commissioned summer 1999. This interconnector was constructed as a double-circuit 220-kV line connecting Tobruk Substation in Libya, approximately 150 km (94 miles) inside the border, with Salum Substation in western Egypt. The 220-kV transmission line extends 165 km (103 miles) and is capable for the commercial trading of 200 MW in either direction. This line extends across the Egyptian desert another 350 km (219 miles) before it reaches areas of dense energy consumption and the load centers of the Mediterranean city of Alexandria. Therefore, the overall length of the transmission line is considered a 500-km (312.5-mile) circuit.

The power system of the Egyptian Electricity Authority (EEA) is interconnected on the eastern boundary of the country with the Jordanian system through a 500-kV circuit that links the two countries via overhead lines and a submarine cable crossing under the Bay of Aqaba in the Red Sea. Jordan is electrically interconnected with Syria, whereas Syria is about to be linked with the eastern boundary of the European grid (UCTE) via Turkey.

Tunisia and Algeria border Libya's western boundary, but until now, there has been no power-system interconnections between these two countries. However, the Tunisian and Algerian power grids are interconnected with two links, and Algeria is interconnected at its western border with Morocco, which is connected with Western Europe via Spain.

The 400-kV AC link with Spain, comprising transmission lines and a submarine cable under the Straits of Gibraltar, connects Mellousa Substation in Morocco with Pinar del Rey Substation in Spain. The “missing link” is the Libya-Tunisia interconnection, which will close the loop of the Mediterranean Basin countries when commissioned.

The Jordan -Egypt Red Sea Interconnection Project

The interconnection project, which will cost the two countries US$200 million, includes a 400-kV submarine cable that crosses the Gulf of Aqaba between Taba in Sinai and Aqaba in Jordan. This link, which is an important stage in the planned interconnection between Egypt, Jordan, Syria, Iraq and Turkey, will be the first electrical connection between Asia and Africa and will eventually lead to a grid loop extending all the way around the Mediterranean. Civil construction started in November 1995. Commissioning of this circuit is planned for mid-1997.

The completed project will economically benefit both countries and will limit the need to install new, expensive power stations to meet the increasing demand for electricity. Different climatic conditions, time zones and peak demand times will increase generating efficiencies and reduce the running and emergency reserves of the two systems, currently estimated at 1000 MW. The link will also improve system stability in the event of multiple outages.

Other Developments The development of the Middle East energy market is vitally important to the economic stability of the area and the continued progress of the Middle East peace process. This market is buoyant with investment in the energy sections in Egypt, Jordan, Israel and the Palestinian self-rule areas. In Jordan, for example, a new gas complex is planned in Aqaba to supply all countries in the region with natural gas piped from Qatar. This project will provide an opportunity to enlarge Aqaba power station and to help meet the rising demand for electrical energy. Recently, JEA and the Palestinian Electricity Authority agreed to increase cooperation between the two utilities with a view to a connection between the two networks in the near future. Similar discussions are occurring between Jordan, Israel and Egypt regarding possible overhead line interconnections.

Future Prospects The Red Sea Cable Interconnection Project linking the electrical networks of Egypt and Jordan will operate with an initial interchangeable energy of 300 MW rising to 2000 MW at a future stage. However, the funding necessary to achieve full utilization of this interconnector and the other developments, including plans to incorporate the Israeli and West Bank networks, are inextricably linked to the success of the ongoing Middle East peace process. The creation of a politically stable and investment friendly climate in the region will ensure continuity in the planned interconnection of transmission networks in Africa, Asia and Europe.

The Spain-Moroco Red Sea Interconnection Project

Project design work started in 1990 with the investigation of alternative schemes based on ac and dc technology to meet the interconnection transfer capacity requirement. REE and ONE's evaluation concluded that the 400-kV ac transmission scheme was the most economic, but the cables for this submarine crossing should be suitable for both ac and dc operation. The dual-purpose cable design offers the possibility of upgrading the interconnection to 2000 MW in the future via dc operation. This 400-kV circuit will be the first installation at this voltage in Morocco, where the existing transmission system comprises 2500 miles (4000 km) of 220-kV circuits. In Spain, similar transmission voltages are used, and the network is comprised of 8000 miles (13,000 km) operating at 400 kV and an additional 9600 miles (15,500 km) at 220 kV.

Power Transfer Contracts The power transfer contract between REE and ONE, which became effective in May 1998, is for the supply of 95 MW from the Spanish to the Moroccan grid. In late 1998, ONE signed a contract with ENDESA, headquartered in Madrid, for the supply of an additional 200 MW to the Moroccan network via the submarine link. While operating as an ac link, additional benefits of the interconnector include frequency control and the capability to respond to power deficiencies in the event of a generator or transmission line failure. To date, the short-term peak load transfer has reached 750 MW.

Technical and Economic Benefits The Spain-Morocco electrical interconnection is an important project that demonstrates that advancing technology enables countries and continents to benefit from power system interconnection.

The project advances the development of the electrical infrastructure in Morocco and significantly improves the stability of voltage and frequency in the region. Both countries are now able to benefit from the improved technical and economic exploitation of the existing power generation and transmission systems in this joint venture that establishes an energy trading facility between Europe and Africa.

The Libya-Tunisia -Egypt Interconnection Project

The first 220-kV circuit — The Coastal Line — is a double-circuit, single conductor (CROCUS/Redwing 412 sq mm [0.64 sq inches]) transmission line that will interconnect Abukamash Substation in Libya with Madneen and Abushama substations in Tunisia. This circuit, which has a route length of 380 km (236 miles), 26 km (16 miles) in Libya and 354 km (220 miles) in Tunisia, is currently in an advanced stage of construction as commissioning is scheduled for October 2002.

The second 220-kV circuit — The Sahara Line — is a single-circuit (CROCUS/Redwing 412 sq mm [0.64 sq inches]) transmission line that will connect Rouais Substation in Libya with Tataween Substation in Tunisia. The total length of this circuit is 298 km (185 miles) — 37 km (23 miles) in Libya and 261 km (162 miles) in Tunisia — and is scheduled to be commissioned by the turn of the year 2003.

ABB supplied and installed the equipment in the Libyan substations at Abukamash and Rouais when first commissioned. The utility awarded Siemens the contract to carry out the required modifications associated with the two interconnections, work that includes supervisory control and data acquisition (SCADA), remote thermal units (RTUs) and the protection equipment linked to the fiber-optic system.

The estimated cost of this major project is US$57 million, funded in part by local currency, the remainder in U.S. dollars.

International Cooperation

The Arab Union of Producers, Transporters and Distributors of Electricity (AUPTDE), and Mediterranean Liaison Committee (MEDELEC) were restructured in 1991. During a meeting in Algeria in 1995, the Mediterranean countries of Northern Africa and South Europe formed EMATLIE, an expert group of seven electric utility chairmen from Spain, Morocco, Algeria, Tunisia, Libya, Italy and Egypt.

The group's main objectives are:

- To exchange technical knowledge.
- To consider the possibility of reinforcing the existing power grids.
- To analyze the static and dynamic behavior of new interconnections.
- To encourage and develop the energy market.
- To establish suitable defense plans.

EMATLIE-established technical committees have conducted many studies and forecast huge benefits in terms of fuel cost savings as a result of the existing and planned links. A comparison between the operation of interconnected networks and separate power systems indicates that this benefit will be 4% per year, somewhat less than the benefits available to the southern European countries that are extensively interconnected.

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8. LARGE HYDO-FUELED GRID SCHEMES FOR AFRICA: A RECIPE FOR DISASTER?"

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Summary

Numerous grand schemes to crisscross Africa with electricity grids are being planned today, with involvement by associations of African governments, foreign donors, the World Bank, and energy companies. Many of these plans rely heavily on new large hydropower projects. NEPAD, the Nile Basin Initiative and the Southern African Power Pool all propose many new large dams, while including in their plans only modest investments in more sustainable energy supply or efficiency measures.

At a time when global warming threatens to make Africa's rivers even less reliable for economically feasible large hydro projects, and their waters more precious for other uses, the energy industry and governments should be looking to increase Africa's reliance on less risky forms of energy supply.

This paper will use the Nile Basin as a case study to discuss the problems with grid schemes that rely heavily on large hydro, and the reasons that good energy planning is imperative for Africa.

The Nile Basin Initiative

The Nile Basin – home to 160 million people in 10 countries, four of which are "water scarce" – has for years been a global hotspot for potential conflict over water resources. The various nations in the Basin have plans to build more large hydro dams and irrigation projects than the river can support. Climate change could worsen this picture considerably.

The Nile Basin Initiative (NBI) was established to address the region's brewing water conflict, as well as reduce poverty and promote economic integration. The proposed program has many positive aspects, and has the potential to reduce a number of problems in the basin. However, the NBI is expected to rely quite heavily on constructing large-scale hydropower dams tied into regional electricity grids to promote economic cooperation. The worldwide record of large dams, as documented by the World Commission on Dams (WCD), reveals that poorly planned large dams are more likely to exacerbate problems of poverty, water inequity and environmental degradation, not solve them. This paper will look at the direction of the NBI to date, the record of large dams in the region, the possibility that its planning process will suffer problems due to its heavy reliance on controversial large dams planned in a non-participatory manner, and better alternatives to meet the region's need for electricity.

Finding the Best Option

A thorough needs and options assessment may very well reveal that some new dams are necessary in the Nile Basin. The key will be to use an open, transparent, thorough review process as recommended by the WCD to determine the best way to meet water and energy needs. The WCD report notes, "Given concerns about a number of barriers that have led to limited assessment of options in the past, it is not enough simply to identify the technologies and policies that can satisfy water and energy needs. It is also necessary to identify the obstacles that prevent the more widespread adoption and use of various options."

While the World Bank – the NBI's key backer and a major strategic player in the development side of its program – has professed its acceptance of the WCD's "core values" and "strategic priorities," it has indicated it will stay away from the stricter and more detailed WCD guidelines. While the Bank has begun to acknowledge the importance of options assessments in planning for water and energy projects – a key recommendation of the WCD – its interest in them seems primarily intended to overcome opposition to large dams it hopes to fund. The Bank also seems unclear about what constitutes a proper options assessment; in a number of cases it has described a ranking of large dam options as an options assessment (for example, in Uganda and Nepal). A 2002 report on power options for the North Nile area, prepared for the World Bank, purports to describe how options assessments could work for some NBI projects, but clearly indicates that hydropower is already a favored choice for electricity.

Alternatives to Dams

The Nile Basin states could take another path, one that would protect the Nile River ecosystem from further long-term harm, and provide needed energy and water supply that is better protected against the vagaries of climate change. A clear process for evaluating the various options is critical to ensure that decisions are fully informed, fairly reached and balanced by citizens' voices as well as those who hold the purse strings.

The Nile Basin has a number of good alternatives to large dams for meeting at least some of its energy and water needs, and indeed a few countries have already begun to develop them to varying degrees. Alternative technologies will be part of the NBI's plans, but the emphasis on large dams will reduce the funds available for renewable energy options and decentralized, lower-tech solutions to water supply. The Kenya-based *Financial Standard* has reported that funding for NBI projects from European nations will include "water harvesting, community-managed irrigation and public-managed irrigation… and community land and water conservation. They will also engage the communities in environmental education and public awareness as well as in wetland and biodiversity conservation." The funds now being devoted to these programs will be much less than what it costs to build a single large dam.[i]

The region has the potential to meet much more of its power needs with renewable energy. Egypt is perhaps the farthest along on establishing renewables in its energy mix. Egypt has very high potential for both wind and solar power, and already derives some of its electricity from both. It intends to install 600 megawatts of wind by 2005. The nation already produces domestic solar water heaters, and is considering solar thermal for industrial applications as well, according to Egypt's Ministry of Electricity & Energy New and Renewable Energy Authority. The agency notes that the potential for grid-connected solar-thermal towers in Egypt "is tremendous and far exceeds all practical expectations for implementation."[ii] The Authority states that the government hopes to build up to 750MW of hybrid solar-thermal/fossil fuel power plants by the year 2010. Egypt also has an energy conservation plan.

Eritrea, too, has very good wind and solar power potential. Uganda has an estimated 450 megawatts of geothermal reserves that could probably be developed more cheaply than large hydropower dams. Kenya is currently generating about 60 MW of electricity from its geothermal reserves, and plans to draw another 576 MW by 2019. Its geothermal potential is estimated at

2,000-3,000 MW.[iii] Ethiopia, Eritrea and Tanzania also have good geothermal reserves, some of which are already being tapped.

In addition to the potential for renewables, Egypt and Ethiopia both have large natural gas reserves. The Egyptian government has estimated that its natural gas reserves are large enough to last one hundred years.

In addition to alternative energy supply, there are also alternatives to large regional grids. While centralized grids do have advantages (such as encouraging energy sharing when some areas are experiencing shortages, and allowing energy sales across large areas), they also have drawbacks. For example, they are usually too costly to be used to electrify poor, rural areas. When breakdowns occur, they can be catastrophic, as recent experience in the US and Europe has shown. Long transmission lines lose energy over long distances, and therefore are more inefficient. Decentralized mini-grids that are locally controlled have numerous advantages: they are less prone to sabotage, can be more built more cheaply and quickly, are more practical for rural areas far from the major population centers, and can be brought online as needed. For the more than millions of people in the Nile Basin without electricity, decentralized energy supply (also known as "distributed generation") is a more practical alternative than large grids powered by large supply projects.

Conclusion

The NBI has an admirable ultimate goal: to provide a peaceful means to reduce conflict in the Nile Basin. It certainly will not be an overnight success, and must be given time for its programs and plans to be fleshed out and tested. But that said, its current direction is of concern. Like its Africa-wide counterpart NEPAD, the NBI may be trying to accomplish too much, while relying too heavily on luring large development schemes to the region as a panacea for entrenched poverty.

The NBI would have a much greater chance of success if it did not repeat the mistakes of the past era of unconstrained dam-building, and if, in the end, it left a healthier Nile River – and Nile River communities – as a legacy. To lay the groundwork for such an outcome, the NBI would benefit from embracing the lessons of the World Commission on Dams. As a first step, the NBI could follow the example of various countries (including South Africa) which have set up inclusive "multi-stakeholder processes" on the WCD, to discuss how best to incorporate the findings into planning processes in the basin. Similarly, workshops to explain the WCD would be useful for the civil society groups involved with the IUCN Nile Discourse Desk. Such programs could take advantage of the Nairobi location of the Dams and Development Project, an UN-sponsored group that is the follow-up program to the WCD.

By taking these steps before making concrete plans to build numerous dams on the Nile, the NBI is more likely to find true "win/win" solutions to some of the seemingly intractable problems affecting the people of the Nile, and avoid having its development program turn into a "lose/lose" development disaster.

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9. THE ENERGY CHALLENGE

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Abstract

The electric utility industry is undergoing a time of uncertainty as the deregulation process develops. This phenomenon not only applies to the United States but to the entire world. After more than a decade, questionable restructuring results in countries such as the United Kingdom, New Zealand or Argentina (to name some of the pioneering cases), give a clear indication of the difficulties and risks involved in the process.

Moreover some serious events have taken place in this country since the inception of the energy reform; notably the California crises in the Summer of 2000, which included the bankruptcy of major traditional utilities, followed by the Enron debacle a year later with its very unfavorable impact on the rest of the industry.

Introduction

A host of celebrated analysts never anticipated the majority of these events. Also, deregulation advocators seem only able to render ex-post explanations of what has happened, most of the time in a context of highly intricate academics. This factor has only compounded the confusion that prevails in this critical sector.

It is clear that there is a major multidisciplinary curricular complexity involved, but there is still an opportunity to return to the energy systems fundamentals to tackle the problem. This has been the philosophy of the Energy Systems Research Center (ESRC) from the very beginning of this process. It is also the time to restate/reformulate succinctly what the goals of the reform are.

First (remaining consistent with federal and state legislation) it has been stated that deregulation was conceived with the purpose of eventually reducing the end-use electricity rates; a second paradigm has been that the process is intended to foster competition among energy players, to some extent to achieve the former.

The first proposition is basically political in that it addresses public opinion. In almost all cases it has been well documented that societal deception has been blatant in that such reduction has not yet happened since the first states began the deregulation process in 1996, more than five years ago.

The second standpoint is even more debatable and can be analyzed in more detail; simply stated, the conduct and performance of the ceasing incumbent utility has had a lot of bearing in the ongoing process. Competition was primarily established at the generation level and ultimately at the retail level with a choice of provider.

The set up has rendered the reformed Investor Owned Utility (IOU) Corporation ill prepared for the transition and obviously incapable to adapt. Plagued with an overall low efficiency, particularly in the power generation area, it would not stand a fair chance to compete with new entrants, even after strained-cost allowances. Moreover the complex old rate structure was inconsistent and contained a myriad of categories, subsidies and cross subsidies, incentives and the sort, making the required clean new scheme, that is substantially marginal-cost based, a doubtful target for retail-service competition. The industry was also falling behind technologically.

Consequently response by the utility companies to these predicaments has been the establishment of a strategy based on a new structure: the affiliate utility holding company. This is a new concept that reintegrates as close as possible the pre-reform conditions, including the tenure of natural gas assets. The idea is to replicate the old monopoly with a strong market power seeking position to offset the aforementioned deficiencies. This has been devised also in concomitance with the emerging market trading business.

New Elements

In this context, there are several tailor-made instruments playing a definite role, this issue has to do with new products and functions created in the new environment, some of which have brought capricious terminology to the field, such as an electric power function unbundling technique named Ancillary Services (A/S), or with new forms of management such as Congestion Management, Risk Management, etc. Associated with this all has emerged the "Independent System Operator/Regional Transmission Operator (ISO/RTO)" ever-changing rules, procedures and protocols. The idea seems to be immersed within a massive fine print impossible to deal with outside the ‘establishment’; this may even include the oversight institutions.

Ancillary Services

The A/S matter has been researched in great depth at the ESRC of the University of Texas at Arlington. There can be a large number of these services, as defined in the different markets; this may be quite cumbersome, particularly for potential new entrants, generating inefficiencies both in functionality and transaction costs. Ancillary Services were originally carried out by the traditional utility through the power pools and control centers of the various hierarchy levels as a single product, however with unknown costs. Today, the affiliate utility system manages to do these services to a large extent, both for its own purposes and within the network, but in a vague market environment. There does not seem to be comparability, but rather a cumbersome new accounting framework. These new accounting techniques, in combination with some price/quantity discriminatory techniques (tying/bundling, price discrimination, gaming, etc), lead frequently to premium prices, substantial volatility and thus considerable financial risk for the genuinely independent players.

Congestion Management

On the other hand Congestion Management relates to the non-discriminatory open access in the transmission system and the physical limitations in the transmission grid due to its finite capacity. This is another intensive area of research at ESRC. Transmission congestion and transmission losses can considerably increase the cost of power delivery. The increase in costs can be important in the case of congestion, particularly when gaming or sham transactions take place, or when software flaws from the network administrator happen. But at this stage in deregulation, the operator (due to unjustifiable technical shortcomings) has gone simplistic: performing only elementary analyses to be able to ascertain/cope with Congestion Management. Basically, only transmission thermal constraints seem to be meaningful to the process. Consequently consideration to other critical elements such as voltage or dynamic stability have been kept outside the operator’s scope i.e. no further power system studies are considered as they could be related to security and reliability. In contrast however, a myriad of exotic risk-management trading instruments have been allowed or promoted in the different markets creating a growing dissymmetry between physical and financial standpoints.

Security

It is known that the utility system was traditionally reliable, nonetheless with an unknown cost/benefit platform. The recognized robustness stemmed from rather conservative planning and operation criteria consistent with the prevailing cost-plus regulation of the monopoly era. The traditional utility power system planning followed a sequence that started with a horizon-year generation expansion program followed by grid development in close consonance in order to meet elaborated performance targets in a quasi-deterministic way.

Such plant expansions were done under dispatch and unit commitment/commissioning logic and grid configuration (base-case approach) that assumed a centralized regulated monopoly of utilities with least-cost objectives in a reliability context.

But the advent of deregulation has completely changed this perspective; the market place of electricity has become very competitive and price-driven, hence the generation pattern prevailing at any particular time follows a random process which may bear little resemblance to the base cases assumed at the planning stages. Under these premises the performance itself of the power system has also been seriously compromised. This has become an undesired outcome of the reform.

The new control centers that FERC is now proposing are based on Regional Transmission Organizations (RTO) as a single control center gathering several Independent System Operator (ISO) areas. This scheme is supposed to cope with the new operational challenges. But the dynamics of a fast changing power system status and its security will further impose substantial requirements: in particular a real-time capability clearly not available today.

The issue of homeland security takes prominence in this whole milieu. Adding to the inherent vulnerability aforementioned, there does not seem to be an approach to address specifically and systematically the target weaknesses associated to generating plants, substations and power grids, neither a remedial action strategy for mitigation and failure containment. Consequently this is an R&D area that deserves high priority.

Recommended Work

It is imperative to formulate energy systems research in order to attain a substantial simplification and consistency for the model of deregulation; this must be carried out within the proper multidisciplinary context if the reform process is to succeed. The determination of what realistic market implementation best reflects the various power system functions and purpose is essential. Research work seeking a framework of equilibrium between physical and economic/financial energy aspects is to be sought; this should be a concept/development process rather than a rule development one, as has regrettably been the case so far.

Looking at pricing issues on Ancillary Services it has been shown at ESRC that there is no physical basis for the kind of volatility experienced in some US markets. The same applies to Congestion Management and to Transmission Pricing/Development. The role of the RTO organization is critical and we contend, if it were properly defined, could be instrumental to achieve both simplicity and effectiveness. This is a pivotal issue whereby the current non-profit status of this organization purports a societal optimal benefit that clearly has not been supported by reality and can easily be challenged. In fact, this stand has just led to an unwarranted lack of competitiveness/accountability, quite apparent in recent times. It has also led to a sluggish operate-by-consensus philosophy. Therefore we believe a great emphasis should be put in restructuring the network engineering management in order to successfully bring high technology, effectiveness and responsibility to this critical function.

Finally the role and extent of the institutional/jurisdictional oversight in the new structure, both regulatory and policymaking, must be analyzed in great depth and possibly reformulated to avoid potential further incoherencies/inefficiencies.

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10. IMPACT OF PRIVATIZATION AND DEREGULATION ON INFRASTRUCTURE DEVELOPMENT IN AFRICA

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Abstract

In an effort to increase the amount of investment funds available for infrastructure development, many Western governments and funding agencies such as the World Bank have been encouraging African countries to liberalize their regulatory policies. The theory is that privatization and deregulation of capital-intensive sectors such as energy will attract investment funds from private sources that will augment the resources available for infrastructure development in Africa.

KEYWORDS: Privatization, deregulation, generation expansion, transmission expansion, Africa, public/private partnerships, energy markets.

Introduction

In this paper, we first describe the technical and structural impact of the various forms of deregulated markets and approaches to privatization of the energy sector. We compare and contrast the traditional approach of publicly owned, debt financed infrastructure development with the new paradigm of public/private ventures financed by some combination of debt and equity.

We then illustrate the benefits and pitfalls of the new approach to energy sector infrastructure development by performing a review of an existing infrastructure project in Africa. Similarly, we draw some lessons from California's experience with deregulation that should serve as a warning of the potential problems that could occur if the deregulated energy markets are not well designed and regulated by a set of sound policies.

We conclude the paper with some recommendations on the forms of deregulation that should be pursued and strategies that could be used to alleviate the most serious problems with public/private partnerships for infrastructure development.

Background

In an effort to reduce poverty and accelerate growth, developing economies have been urged to deregulate and privatize sectors, such as the energy sector, that require significant investment in infrastructure. The World Bank has been promoting these strategies and, through the International Finance Corporation (IFC), providing low interest loans to finance joint public/private projects to develop infrastructure on a Build-Own-Operate-Transfer (BOOT) basis. Under this scheme the government or local utility becomes the owner of the plant after the private investors have recovered their original investment over a number of years (typically 15-30 years).

Project Financing and Investment

Traditionally, governments have publicly financed infrastructure projects in many developed and most developing regions. In the energy sector, this was achieved through a national or regional, vertically integrated utility. Given the difficulty of obtaining the necessary debt financing, there has been a move over the past decade to encourage private participation in infrastructure investments. Large infrastructure projects are now organized under complex ownership and financial structures designed to appropriately spread risks, assign costs and allocate benefits. Whether or not the intended objectives are met depends on the negotiating abilities of the various parties. It is very difficult to analyze and understand the ramifications of all the terms of the complex Power Purchase Agreements (PPAs) that support these projects without a sophisticated financial and risk management model. Even when fair contracts have been negotiated, the outcomes are dependent on the actual outcomes that obtain over the life of the contract. Thus, for example, an economically viable project may end up bankrupt if input costs rise unexpectedly under a regime of fixed retail rates.

Public Private Partnership (PPP) Project Structures

The major dimensions under which PPP projects are structured are ownership (public, private, foreign, local), and financial structure (equity, debt and grants) [1].

The traditional public ownership of infrastructure projects is being eschewed in favor of private participation. Private ownership can be either through a joint venture with the government (or the local utility) or for a period of time after which ownership is transferred to the utility. In the second approach, the private investor builds, owns and operates the plant for fixed a period after which the plant is transferred to the utility. This is now the more popular approach since the private investor has full control during the building and initial management and operations of the plant. This gives the utility staff time to develop and acquire the necessary expertise to take over the running of the plant. Since local capital is usually unavailable to support infrastructure projects, the private participation is usually through foreign direct investment. In order to encourage local participation and local capital formation, some governments may require a certain level of local private participation.

Infrastructure projects are typically financed using a combination of equity and debt financing. Since equity financing is via risk capital, it is expected that only the more risky, but viable projects will attract such investments. However, equity investors require a higher rate of return and as such the overall project costs may be higher.

Project Negotiations

One problem with PPPs is that less developed countries in Africa are not a in a position to negotiate favorable contracts with large foreign firms whose annual sales may exceed their GDP. Foreign firms not only negotiate from a position of strength but also tend to overestimate the risk involved with these types of projects [2]. They therefore impose onerous contractual terms and require very high rates of return that, in the case of electricity, results in very high take or pay tariffs that the government or local utility has to impose on the local population. Furthermore, the resulting projects tend to have high capital costs and expenses based on western wage rates and expenses.

Unlike telecoms that have seen an explosion of new services and rising levels of private investment, large infrastructure projects have not been subject to any significant competition since companies that win infrastructure development projects tend to include lock-out clauses in their contracts that limit the ability of the government to embark on new projects.

Since energy growth is a key driver of development, there continues to be a role for government to invest and subsidize the energy infrastructure as long as it can do so effectively. While competition is viable at the generation level, with some caveats, transmission remains a monopoly that should be regulated as a common carrier to ensure that power generators will have access to the transmission grid to deliver their power.

A similar argument holds for distribution systems; distribution companies, whether public or private will remain monopolies and should be regulated as such.

Generation has become relatively straightforward to liberalize and allow competition. Generating plants can be supported by long-term power purchase agreements (PPAs) with a payment structure comprising capacity payments plus a price for energy generated. The problems associate with pricing and paying for transmission with an integrated grid are minimized for interconnections. The builder of the line can sign a PPA based on the line capacity and the value of the energy imported or exported using the line. Of course the agreement will be more complex than a standard generator PPA since power could flow in either direction on an interconnection and the investors will have to negotiate two governments and two state-owned utilities.

The California Experience

The well-documented energy crisis in California [3] at the turn of the 21st century illustrates the problems that can befall even a sophisticated economy when liberalization of the energy sector is carried out too quickly and without ensuring that appropriate safeguards are in place. While many reasons contributed to the energy crisis, the three areas in which developing countries can draw useful lessons are in 1) the low level of infrastructure built during the 1990s, 2) the structure and types of contracts the utilities were allowed to sign, and 3) the speed with which the energy industry was deregulated.

In the case of infrastructure development, California's cumbersome permitting process made it very difficult to build generation. Private investors preferred to build in states where projects could be approved in a timely manner and as such California's reserve margins declined. The problem was not immediately evident because the state was able to import significant amounts of power from its neighbors. However, as the neighboring states' economies, and hence demand, grew the amount of power available for import fell. The reduction of energy available from hydro during a dry year was sufficient to trigger widespread shortages.

The second factor from which lessons could be drawn was the structure of the contracts in place after the deregulation. The utilities were encouraged to divest of all their thermal generation but were not allowed to sign vesting contracts that could have provided some price certainty for an initial period. This would have provided some time during which all players could have adjusted to the new market. Instead, the utilities were required to purchase all their requirements from a day-ahead spot market. As such, all their purchases were exposed to volatile prices.

The third factor that holds lessons for African governments liberalizing their energy sectors was the fact that California's energy industry was restructured very quickly. The wholesale market structure was implemented in one step, with the only transition mechanism being the fact that retail rates were to be kept fixed for at most four years. The utilities were supposed to collect their stranded costs during this time period but when their costs rose above the regulated price one of the three major utilities ended up bankrupt.

The Bujagali Hydroelectric Project in Uganda

Bujagali is a 200 MW hydropower dam project on the Victoria Nile in Uganda. One of the largest private power projects in Sub-Saharan Africa, and the largest private investment in East Africa, it is being developed as a public private partnership BOOT project supported by a 30 year PPA. The private investors were originally led by the US-based AES Corporation, one the world's largest private power producer, until they pulled out of the project in August 2003. The World Bank supported the project and the IFC provided debt financing to the Ugandan government for its portion of the project. Project costs are estimated at $580 million with an 80/20 debt/equity ratio.

In an analysis of the PPA [4], the authors concluded that the project was about twice as expensive as a comparable hydro project. The complex PPA had the Ugandan government bearing most of the risks of adverse foreign exchange movements, operational risks during dry years and the financial risks if interest rates rose.

The project was negotiated with a single consortium of private investors and no competitive process was used to strengthen the negotiating position of the government and ensure that lowest costs were obtained. Since the size of the project is so large, the capacity of the Ugandan government to engage in other power projects is limited and in fact, the PPA explicitly prohibits the government from entering into other contracts until the project achieves financial closure.

The Effect of Globalization

Developing economies in Africa currently have little choice but to participate in the dominant global approaches now being promulgated by international agencies. However, the lack of the ability to negotiate international trade and investment agreements effectively results in projects where the government bears a disproportionate amount of risk and pays a very high price for the invested capital [5]. This problem will have to be addressed by governments finding, nurturing and engaging reliable partners. For-profit global power companies are unlikely to be suitable for such roles since they are beholden to their shareholders to show returns on investment commensurate with the risk of an infrastructure project. Even the local partners that most developing regions insist participate in these projects are not likely to fit the bill. Indeed, many of these local minority partners are merely partners of convenience and, since they normally do not bring any significant investment to the table, tend to defer to the majority partner whose capital is at risk.

Suitable partners will have to be knowledgeable and skilled and they have to be aligned with the objectives of the government. A similar model has worked well to date for the technical consulting and advise that governments have sought during the planning phase of projects. One possible option that governments have is to engage a partner who will take an equity stake in the project but whose returns will be based on how well the government objectives are met. These objectives can be non-monetary goals such as number of jobs created or financial such as minimizing the rise in electricity rates. Of course, crafting this type of contract with a partner, possibly from the developed world, will take some skill from government.

Conclusions

In the drive to accelerate development, reduce poverty and replicate the success of Asian economies, the current approach to developing infrastructure in Africa through market liberalization and public/private partnerships holds significant risks for its developing economies. The difficulty in negotiating fair contracts that balances risks raises questions about the desirability of these very large projects whose risk may be unacceptable. A more acceptable approach could be to focus on a portfolio of many smaller projects. The economy would then be less susceptible to impact of a delay or failure of any one project.

We therefore recommend that government establish and train a cadre of legal, financial and technical experts to negotiate contracts. All contracts must be by competitive tender. In order to minimize the risk of unintended consequences, PPAs and similar contracts should be kept as simple as possible and standardized whenever possible. The government should endeavor to introduce genuine competition be among foreign competitors during project selection in order to strengthen its negotiating position.

Debt financing of least cost planned expansions should be used whenever possible. This will provide governments with better control over their energy destiny. Equity investments should be reserved only for the highest risk projects.

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Biography

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11 STATUS OF INTERNATIONAL INTERCONNECTIONS AND ELECTRICITY DEREGULATION IN AFRICA—AN OVERVIEW OF THE CURRENT STATUS IN SOUTHERN AFRICA

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Abstract—The Southern African power system is in a state of flux. The grid is expanding and more interconnections are being made. However, vastness of the area and the low power consumption density in most African countries makes the operation of the interconnection difficult. Some of the utilities are also being privatized to improve their financial and system performance.

Index Terms—Deregulation, power grid, Southern African Power Pool, stability.

INTRODUCTION

Reliability and stability in the electricity supply industry is a key component to the sustained economic development of a country or a region. Developments over the last eight years since the establishment of the Southern African Power Pool (SAPP) have helped to stabilize and improve the interconnectivity of the grid.

SAPP and Interconnections

Africa is a vast continent. In Africa south of the equator only South Africa has a well-developed and meshed grid with large generating capacity to support industry and development. Most of the southern African counties are in one way or another dependant on South Africa for supplying the balance of the power consumed and in stabilizing their grid. This is achieved by co-operation within the Southern African Power Pool. The SAPP consists of the state-owned utilities of Botswana, Democratic Republic of the Congo (DRC), Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zimbabwe, Zambia that are all interconnected. The total maximum demand of SAPP was 35,9 GW in 2001/2 of which South Africa consumed 30,6 GW. The total installed capacity is 48,3 GW with the South African contribution 41,3 GW.

Typically South Africa's neighbors produce most of their own power. South Africa produced 87,6 % of the consumed energy in 2001/2.

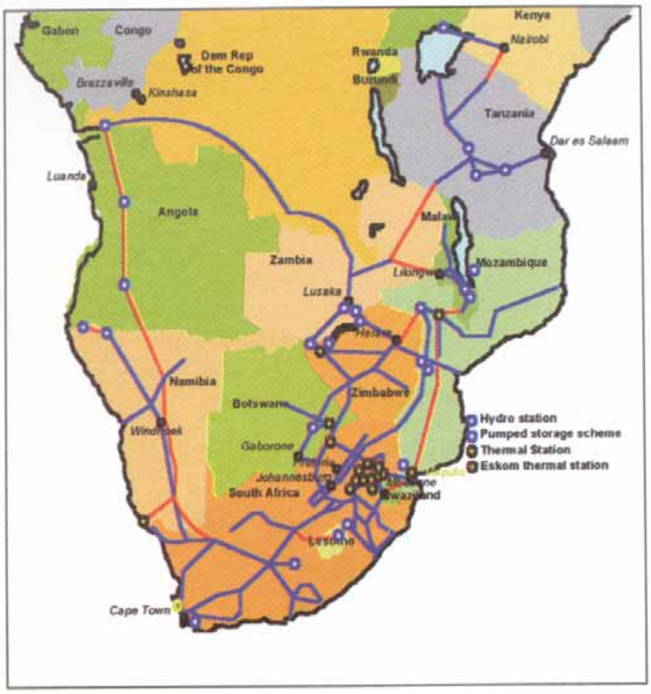

Figure 1. Southern African Power Pool grid [1].

The blue lines in Figure 1 indicate the interconnected system and the red lines the plans to expand the interconnection. With the proposed interconnections to Angola, Malawi, Tanzania and Kenya the national grids in Angola, DRC, Namibia, Mozambique, Tanzania and Kenya will be strengthened. This will also improve the stability of the system and be of general benefit to all the countries in the region.

Power system stability

The SAPP main grid is stable and the frequency control is good [4]. This applies to the main grid connections. However, the level of interconnectivity in counties outside South Africa is low. This means that faults and power swings can have a severe effect on the stability of the grid.

The generation is able to meet the current load requirements. The growth in the region is putting pressure on the reserve capacity that is current available. New power plants have to be built, but financing these projects and environmental issues are delaying the start of the projects.

Industrial Consumer view

The vastness of the area and the low power consumption density in most African countries makes the operation of the interconnection difficult from an operational point. Many of the loads are connected to spurs off a grid that has a low level of interconnectivity. In addition, most of the networks have suffered from a lack of maintenance due to a shortage of funds. This has dramatically reduced the reliability of the system and outages frequently occur in many places.

The combination of these factors has forced industries to provide their own generating facilities in the form of diesel power. These plants then operate in island mode and will often also provide power to towns and villages in the immediate vicinity of the plant.

Some utilities are discouraging this practice, but need to convince these clients to connect to a grid that may not be that reliable in the first place, particularly in areas connected to spurs [2], [3].

Deregulation of the utility industry in Southern Africa

Very little true deregulation of the utilities in Southern Africa has taken place. Some attempts are currently being made to deregulate state owned utilities. South Africa and Tanzania are starting to make progress is this regard. In South Africa there are plans to partially privatize the national utility. The generation and distribution sections are being targeted. The transmission system will stay a utility. This will also open the door to medium-sized independent power producers. In Tanzania two independent power producers have been established and the state-owned utility is preparing for unbundling and privatization.

The deregulation process is difficult to manage. Labor unions are opposed to the unbundling and privatization of utility companies in two countries. This delays the process and creates uncertainty in the minds of potential investors. The knock-on effect is that less money is being spent by utilities in upgrading system. Utilities therefore depend on loans from the World Bank, the state and donor countries' funds to expand and upgrade their networks.

Donor countries are providing funds for consultants to analyze the performance, reliability, sustainability and financial systems of utilities. This is helping to get many of the utilities back on their feet by ensuring better financial and technical management.

Summary

The situation in the SAPP is steadily improving and a short-term energy market has been established between the various utilities. Key projects are also in the pipeline to improve the generation and transmission capabilities within the SAPP.

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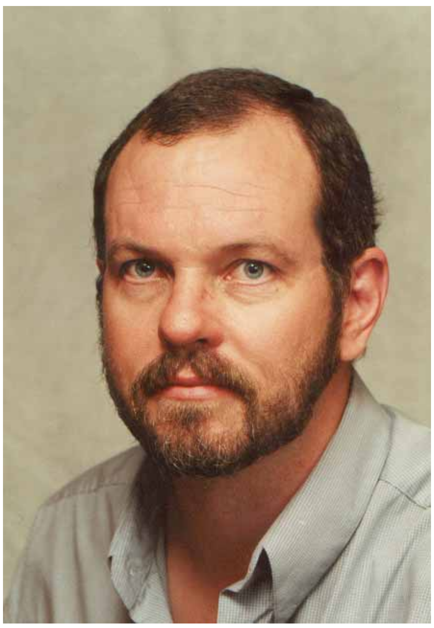

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